ADDENDUM TO
DIVISION AVENUE PUMPING
STATION & FILTRATION PLANT
(Baldwin Filtration Plant & Reservoir of
the Cleveland Water Supply System)
Kentucky (38th Street) and Franklin Streets,
Division Ave.
Cleveland
Cuyahoga County
Ohio

HAER No. OH-3

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Historic American Engineering Record

Division Avenue Pumping Station, Filtration plant and the Baldwin Filtration Plant and Reservoir of the Cleveland Water Supply System.

HAER OH-3

Location:	Kentucky (38th St) and Franklin Streets Division Avenue Cleveland , Ohio Cuyahoga County
Date of Construction:	c. 1856-1869
Present Owners:	City of Cleveland
Present Use:	Water filtration and pumping
Singnificance:	The two plants represented state-of-the-art technology for water treatment. With their additions over the years they have supplied sufficient clean water to the citizens of Cleveland. The construction of the two plants evidenced several innovative movements in the history of technology as applied to tunneling the treatment of water.
Historian:	Ed Pershey, 1978

"With reference to Cleveland, the most prominent difficulty presenting itself to the citizens, is to obtain pure water near the city, unaffected by town drainage, and the discharges of the Cuyahoga River".2

Theodore R. Scowden
Water Works Engineer
1853

This historical report on the Division Avenue Water Plant and the Baldwin Filtration Plant & Reservoir of the Cleveland Water Supply System rests formally on the sites themselves and the sources cited in the notes, but in reality owes its existence to the help and cooperation extended by numerous city officials, especially those of the Water Department. John B, Nash, administrative officer in the water commissioner's office, not only discussed the department at length but offered free use of historical material which he had collected and saved from the garbage heap over the years. Mr. Nash served as a liason with the rest of the department as well. Mrs. Frances Bencin, in Utilities Engineering, made the search for and use of engineering drawings of the system a relatively painless procedure. Utilities Commissioner Louis Coris and Acting Public Utilities Commissioner Julius Ciaccia, although not directly involved in the day-to-day research work, were both highly accessible and cooperative in providing the necessary authorizations for use of material and access to the sites. William Mucci, head of pumping, and his assitant Frank Brooks, who made the Division Avenue inspection a real learning experience, were not only cooperative but highly sensitive to the HAER survey work. James Jerreris, head of filtration, was an informative friend whose tour of the Baldwin Plant brought that facility into unique perspective. Thanks go the Mrs. Cindy Darwal, of the Commissioner's office, who worked hard in coordinating the HAER work with the daily operations of the department. Special thanks must go to John Wolfs, of the Cuyahoga County Port Authority, whose long friendships with the water department personnel made the initial contacts smooth and immediately fruitful. As she had done for the whole summer 1978 recording project, Mrs. Margaret Warden, in charge of the Cleveland Picture Collection in the History section of the Cleveland Public Library, bent over backwards to allow copying of important photographs. The U.S. Army Corps of Engineers, who provided 80% of the funds for the whole summer project, also allowed the use of their boat to gain a close-range view of the water intake crib located 4 mile out on Lake Erie.

This cooperation of the Water Department of the City of Cleveland comes at a critical time for the water supply system. The last of the city's <u>revenue-generating</u> utilities, which provides water to the surrounding suburban communities, the department, in 1978, has begun to be affected by the growing financial crisis of the city of Cleveland. Substantial amounts of the department's captial improvement fund are being borrowed by the city to meet general municipal operating expenses. Belt-tightening, a constant public service process, has in 1978 especially affected in the water system which had been run in recent years in a short-sighted, penny-wise manner in a successful attempt to keep the Cleveland water rates some of the lowest in the country. At the writing of this report, the city's ability to repay the borrowed water funds and the transfer of the whole water system to a regional governing body are two questions only now being raised. The HAER study could not have come too soon.1

I LAKER ERIE AS A WATER SUPPLY

The City of Cleveland sits at the midpoint of a 40-mile long, 7-mile wide bay on the southern shore of Lake Erie. The lake holds over 100 trillion gallons of water.[3] It is not surprising, then, to find that the development of the Cleveland water supply system is essentially the story of the city's efforts to draw drinkable water from the lake. As with so much of technological-industrial Cleveland, Lake Erie has been the defining force in shaping the city which reflects the potential, limitiation and parameters of nature's lake.

Drinking water and general water supply for Cleveland did not always derive from the lake. Until the mid 1850's the main sources were spring wells located throughout what is now the downtown area.[4] The first public well early in the 19th century was dug on Bank Street near Superior Street (W. 6th Superior) and was eight feet across. However, spring fed well water proved too hard (high mineral content) for use in washing, and there was a ready market for the watermen who hauled lake water to the citizens, charging by the barrel.[5] In 1840 the City Council authorized the Supervisor of Streets to dig public wells of 3 1/2 feet diameter as long as the cost per well was less than $35.00.[6]

Larger scale efforts to provide a continuous supply of water did not succeed. In 1833 the Ohio Legislature incorporated the Cleveland Water Company, under a group headed by one Philo Scoville, whose charter required them to supply water to the citizens of Cleveland. Except for the collection of funds through the sale of stock, and in spite of a legislative amendment in 1850, the company never materialized, no water ever delivered, and very little is known about the plans or the men behind it.[7]

In 1845 a group of investors promoted a real estate development on the east bank of the Cuyahoga River on Oxbow Bend, to the south and west of Public Square. Since even by then the river water was not suitable for drinking purposes, the investors devised a water delivery system, using as a source a spring on Willeyville Hill west of the river. The spring water was first collected in an artificial timber and brick well, then piped to a 13,800 gallon reservior, and finally carried another 500 feet in pipes to the river bank. Pipes laid under the river carried the water to Cleveland Center, the name of the new development. The system had a capacity of 1,600 barrels (approx. 50,000 gallons) per day. The water system disappeared with the real estate venture.[8]

By the early 1850's the City Council in Cleveland decided that a water system supplying the whole city from a dependable source more extensive than individual wells was needed to meet the needs of a city which had boomed in the 25 years following the opening of the Ohio Canal. In 1852 a committee headed by Mayor William Case was formed to study three possible sources: Shaker Mills, Tinker's Creek and Lake Erie.[9] After some delays caused by surveyor's errors, the committee reported late in 1852 with these recommendations:

1) a reservior in the form of a water tower be erected near Euclid Street in the heart of the city to provide sufficient pressure for firefighting, which well springs could never provide;

2) a low service reservior for normal drinking and washing supply;

3) the reservoirs to be fed by pumping engines run by steam power (preferably Cornish design engines);

4) the work to be municipally built, owned and operated;

5) the water to be drawn from Lake Erie;

6) and that the city hire Theodore R. Scowden waterworks engineer in Cincinnati, to plan and supervise the construction.

City Council adopted the report on March 22, 1853.[10] That same yar the council also approved the sale of $400,000 in bonds for the establishment of Water Works Trustees and the erection of the works.[11]

With the hiring of Scowden, and his first report in 1853, the municipal water works of the City of Cleveland began to take shape. Although no part of the original installation remains, and all but four engineering drawings have been lost or destroyed with very few photographs or engravings surviving, the design of the system was to determine the future development of the Cleveland water system, and so deserves description. Also, the site chosen by Scowden has been occupied by the water department continuously since that time, it being the site of the present Division Avenue Pumping Station and Filtration Plant.[12]

Scowden prepared three different systems, one of which was adopted by the city council. The plan approved for final construction followed the recommendations of the committee of 1852, except that it abandoned the high level water tower on Euclid Street, even though Scowden had originally designed it for one of the other plans substantial structure with "such embellishments" as " would give fine effect to the appearance of the Tower, and lend great attraction to the spot, as a place of public resort."[13] What apparently scuttled this tower was the annexation of Ohio City, on the west bank of the river, which was generally on a higher plateau than the city of Cleveland and afforded a site for a reservoir high enough to obviate the need for a tower.

The system approved by the council was to supply an area bounded by the lake on the north, Erie Street (E. 9th) on the east, the Cuyahoga River on the west, and Eagle Street on the south--a total area of about 1/3 square mile--using 11 miles of pipes. A pumping station located near the shore of Lake Erie, at the foot of Franklin Street, on the city's newly acquired west side, pumped water from the lake to a high level reservoir, also on the new west side, just south of the station, from which the water would be gravity fed to the city. The pumping station was eventually located at the foot of Kentucky Street (W. 38th), with the reservoir at the corner of Kentucky and Franklin Streets.

Water from an inlet crib about 300 feet out into the lake traveled by aqueduct from the submerged pipe, around the west bend of the Old River bed, thence eastward to the pump house. The pumping engines, sucking the water out of a rising well, forced the water up to the reservoir.[14] By drawing the water from 300 feet off shore, Scowden felt that in regards to a supply of pure water ". . . the citzens have no occassion to fear that the lake water may ever be contaminated ...to a degree impairing its pure and healthful quality, at the point where the water flows into the aqueduct pipe for the supply of the pumps."[15]

Scowden estimated that the completed system, designed to supply 100,000 inhabitants, could easily supply a city of twice that population and with "an enlargement of the main pump barrel and plunger to each Cornish engine, which was comtemplated in the plans" the system would be able to serve the city for fifty years.[16] As far as the pumping engines themselves were concerned, Scowden's prediction came true, but the system as a whole became outgrown within 15 years. Two major elements of Scowden's design, the pumping engines and the reservoir, deserve description before we assign them to the historical junkyard.

The engines selected for the pumping were an English design called Cornish, because the type had developed and been perfected in the Cornwall mining district in England for the drainage of mine shafts. They were particularly well adapted to the purposes of pumping water. The Cleveland engines were ordered from the New York Allair Works owned by Commodore Vanderbilt.[17] Two engines were ordered, to be worked alternative weeks, so as to always have a duplicate, back-up pumping system. Total cost of the two engines, including construction, transportation, on-site erection, furnaces and chimneys came to $80,320.[18] The cylinders had a diameter of 70 inches and a 10-foot stroke. The beam was double and unequal, with arms of 15' 11' and 13' 11 1/2", and was 6' 8 wide, weighing 40 tons. At nine strokes per minute (an average running speed) the engines attained 120 h.p., though they were apparently worked slightly faster, and could generate up to 200 h.p. The pump plungers were 30 inches in diameter, and moving through a stroke of 8' 9" raised 320 gallons of water per stroke to a height of 150 feet.[19] A description how the engine worked was given in 1900, at which time they were still occassionally used:

> When steam is admitted above the piston, the space below it is placed in communication with the condenser when the preponderance of pressure upon the upper side forces the piston downward, raising, by means of the walking beam, the plunger and the larger counterweight over it. At the end of the up-stroke the steam admission valve in the exhaust pipe leading to the condenser are closed, while the valve in a pipe connecting the upper and lower ends of the cylinder opens, equalizing the pressure above and below the piston, which allows the counterweight to force the plunder downward and the water out through the discharge valve. A steam pressure of only 21 pound is used, but a vacuum of 26 1/2 inches is usually obtained. The barrel of the steam cylinder is steam-jacketed. The valves are of the poppet type, operated by cams on a rockshaft driven from the walking beam. The cut off on the steam valve and the closing of the exhaust valve may be adjusted independently by means of a screw connected with the valve driving rod. The condenser is of the jet type and the air and boiler feed pumps are both driven from the walking beam. The boiler feed pump draws water from the condenser discharge.20

The Cornish engines were the first of their type built west of the Alleghenies and were the pride of the city as well as the water works.21

By 1862, however, the high level of efficiency of the engines has dropped, due to their age and a new system of more exact measurement of coal consumption.22 In 1871, increasing water consumption meant that either the two Cornish engines must pump together, or that new engines be installed. In order to preserve the back-up safety design, new Duplex (double-acting) steam engines were ordered from the Cuyahoga Furnace Company of Cleveland. After installation of these pumps, and another set of Worthington Duplexes in 1874, it became apparent that the new pumps so lowered the level of water in the suction well of the aqueduct intake from the lake, that the intake tubes of the old Cornish engines no longer reached completely below the water level, and could not operate efficiently, and at times of low water conditions not at all.23 Thereafter the Cornish engines were used sparingly.24 In 1884, because space at the Division Avenue plant became valuable for the installation of newer equipment, the Cornish engines were moved to the new Fairmount pumping station on the east side.25 They were used intermittantly there, even though with reinstallation and a cleaning they proved to work at a high level of efficiency, and with less vibration than had been the case at the west side station. The boilers were outfitted with smoke prevention devices, which also improved the engines' efficiency.26 They remained at Fairmount in good working condition until 1906, when they just plain outlived their usefulness and, although still in good working order, were dismantled and became the property of the private contractor hired to do the work, who presumably junked them for their scrap value.27

The Cornish engines at the Kentucky Street station had been housed in an engine building of brick with stone caps, sills, and cornices. The building meaured 105' across the front, with a center two-story structure 46' c 55' and two wings each meauring 29 1/2' x 52 1/2'. A stand pipe, 170' high, was topped with an observation lookout reached by spiral stairs.28

The new reservoir was located south of the pump house at Kentucky and Franklin Streets in old Ohio City. The grounds covered 6.15 acres, and the base of the reservoir itself covered four, measuring 332 x 466'. Built of earthen embankments, and lined with an impervious clay puddle and hard-burnt brick laid in hydraulic mortar, the reservoir held 6,000,000 gallons of water in two compartments separated by an earthen wall. The retaining and dividing walls sloped 1 3/4 to 1 on the inside, and 1 1/2 to 1 on the exterior; retaining walls measured 100' at the base by 15' across at the top, while the dividing embankment was similarly 52' x 10'. The water depth was 20 feet, with the water level, when the reservior was full at an elevation of 150 feet above the lake. The bottom of the reservior was slightly over 112 feet above lake level. Raw water was fed into the reservoir through a 24" diameter pipe, and drawn out by two 20" diameter outlet pipes or an overflow pipe of the same size. The community received the water untreated in any way.29.

On top of the reservoir walls an 8-foot gravel walk ran around the perimeter, with an iron lattice fence at the edge of the open water. A stone walk leading from Franklin Street allowed public access to the reservoir walk which became a fashionable place for social promenading (HAER photo).30

The needs of the city outgrew the 6,000,000 gallon capacity by 1875, but the new Fairmount Reservoir was not opened until 1885. Beginning in that year all the water for the city was pumped to Fairmount, and the Kentucky Street Reservoir deactivated. It sat, full out unused, until 1886 when it was drained and used as a storage depot. By 1890 the land was no longer listed on the property of the city water works, and had been converted to a park. The spot, now labled "Fairview Park" contains public gardening space in 1978.31

The complete system opened in 1856 cost $513,598.51, and served a population of 30,000. The average daily pumpage in 1857 has been listed as 348,000 gallons, although either of the Cornish engines working at nine strokes per minute could have easily pumped over 3,000,000 gallons in a 24-hour period. By 1869, the needs of the city had begun to outgrow the 3,000,000 gallon daily level, although only a quarter to a third of the population actually received water from the system.32 By 1874 the Cornish engines had been pushed to their limit, pumping in June of that year, just before the installation of new engines, over 6 million gallons per day, more than the total capacity of the Kentucky Street reservoir.33 But by 1874 the first lake tunnel had been opened, a new engine house built, and plans had been drawn for new reservoirs and additional supply mains. With the opening of the intake tunnels, water was pumped directly into the system, the reservoir acting simply as a pressure equalizer and regualtor "floating" on the supply line.34 The Cleveland water works had been expanding vigorously since 1869, and this energetic growth, at times highly daring and enthusiastic, would last until the opening of the Baldwin Filtration Plant and Reservoir in the mid 1920's.

On August 23, 1869, the first shovels of dirt turned over out of the hole that was to be the shaft of a 6600-foot tunnel under the lake bed which would bring water from over a mile out in the lake to the Kentucky Street station. Before construction ended 4 1/2 years later, seven workmen died trying to lay a brick and mortar "pipe" through the clay and sand under Erie's bottom, to form the water supply tunnel that still in 1978 supplies part of the water processed at the Division Avenue Plant.

Chemical tests of the purity of the water surrounding the first intake pipe 300 feet out had showed a marked increase in solid, suspended matter, but the residents of Cleveland in the years immediately following the Civil War needed only their tongues to know that the water was not right--it tasted of petroleum.35 The only way to avoid contamination of the drinking water by the discharges from the Cuyahoga River was to move the intake pipe out further into the lake, where the polluted river water could become sufficiently diluted by the purer lake water.

The tunnel can actually be described as a hand-dug pipe, using the density of the clay for the form, or hole, and brickwork as a system of annular bracing. As built it was slightly elliptical, with a vertical diameter of 5 1/6 feet by a horizontal diameter of 5 feet. Since it has not been drained and inspected since the construction of the adjoining 10-foot tunnel in 1913-16, it is assumed to be in a state comparable to that when built. A lake shaft of 8-foot diameter, protected at the surface by a wooden, pentagonal crib, reached the tunnel at 90.5 feet below average lake water level. A similar shaft on the shore met the tunnel at a depth of 67.5 feet (the tunnel rising to prevent the flow of sand into the suction wells on shore). The lake shaft from the bottom of the lake to the crib was actually a cast and boiler iron pipe, standing on end. Water flowed into the shaft and into the tunnel over the top of the iron pipe, which was left open nine feet below water. Two sections of iron shafting, stored on the cirb, could be set onto the top of the shaft, extending it above the water line, acting, therefore, as an on-off gate for the supply of water to the tunnel.36

All excavation in the tunnel was by human hand, transported out on a small guage railroad. Each car held 20 cubic feet of earth or 400 bricks. Cars were hauled up or down the shafts by steam driven elevators, and along the tunnels by mule or manpower. The average daily completed tunnel section was just under 10 feet. A tin pipe channeled forced air for the workers into the tunnel.37

For a 140-foot section of the work, a moveable cast iron tube section, a shield, was pushed by hydraulic ram through clayey sand that threatened to fill in as fast as it was excavated, before the retaining brickwork could be laid. For most of the 6600 feet, however, the clay itself provided sufficient stiffness to allow simple excavation and the laying of annualr brickwork to form the tunnel. At places where the tunnel curved, the facing of the bricks received a thin layer of hydraulic cement mortar to promote the smooth flow of water through these non-linear segments.38

Two of the deaths recorded as construction related were the result of the explosion of natural gas in the tunnel. Pockets of gas in the sand and clay under Erie's bottom continually plagued the crews. Three of the other four deaths were the drownings of me begin transported out to the intake crib. The last death occurred on the crib when a workman fractured his skull in a fall off the lattice work of the crib. These misfortunes did not brand the work as a jinx, for the difficulty of tunneling under the lake was understood to be a risky venture. In fact, the Board of Trustees of the Water Works praised the contractor, in their report on the completion of the tunnel, for his "energy and determination to overcome all difficulty, and for the faithful, substantial and satisfactory manner in which he executed a work demanding at all times the utmost care and watchfulness."39

The 1874 tunnel could supply 40,000,000 gallons of water per day (40 m.g.d.), and this was far beyond the pumping capacity of even both the Cornish engines running at full speed. The Cuyahoga and Worthington Duplex engines were brought in to handle the increased water flow. Much of the water needed to be pumped directly in the system , because of the small capacity of the old reservoir, and the Cornish engines could never have provided the volume or pressure required for this. New engine houses at the west side pumping station were built in 1874 and 1897, by which time the type of engines being installed were triple-expansion Holly and Allis behemoths. Reservoirs on the east side now served the city, the main reservoir, Fairmount, located high above the level of downtown structure, built in 1885, remains an active part of the Cleveland water system in 1978, serving as the raw water storage for the Baldwin Filtration Plant just to the south. New engines and the old Cornish engines provided direct pumping from Fairmount Reservoir to low, first and second high service areas.40

By this time, the Cleveland system had begun to take shape as a series of plateaus of water delivery service. The land along the lake, up to an elevation of 120 feet (or 30 feet below the head produced by the old Cornish engines) became the low service district, fed water either by gravity from the east side reservoirs or by direct pumping from the Division Avenue station (the station acquired the name Division when the new east side facility, Fairmount, was opened in 1886) along the lakefront.

Land at elevations of 120 to 250 feet became the first high service district, that at 250 to 500 feet the second, and eventually a third high district area developed in the suburbs where the elevations above lake level ranged from 500 to 810 feet. These high service districts received water from direct pumping or later from water towers. A good example of the often abrupt demarcation between service levels occurs at the Fairmount-Baldwin site. The 19th century open reservoir, Fairmount, is located at the bottom of a steep incline, just to the north (lakeside) of the Baldwin Filtration and Reservoir complex. This incline is the border between the first high service and second high service plateaus, the two facilities occupying two distinct service levels.41

The system completed and in operation as of 1900 was composed of an enlarge Division Avenue Pumping Station, on the west side, a large reservoir on the east side fed by Division pumps (Fairmount Reservoir), a pumping station fed by this reservoir (Fairmount Pumping), and a smaller first high service reservoir also on the east side. The next twenty-five years were to see the development of two major facilities: a new Division Avenue Filtration and Pumping Plant on the same site as the nineteenth century installations dating back to 1856, and a completely new Baldwin Filtration Plant and Reservoir on the east side, above the old Fairmount Reservoir. The histories of the two plants, although connected by other development in the system, run in different paths and time slots, with deviations of quite different character. The chronological arrangement of this report will split into two here, to consider first the Division Avenue site and then the Baldwin site. Included in the first will be a discussion of the construction of the associated west side tunnels, and in the latter information about the Kirtland Street Pumping Station, the east side tunnel and lake intake cirb No. 3.

II DIVISION AVENUE PUMPING STATION AND FILTRATION PLANT

The Present facilities on Cleveland's near west side shoreline, known as the Division Avenue Pumping & Filtration Plant, date from the period 1914-1918 on a site which has been occupied by the Cleveland water system since 1856. The pumping station was built in conjunction with the extension of the west side tunnels (the original 5-foot and the 1891 7-foot tunnel which also rant to the same lake intake crib) from their junction to a point 16,000 feet further into the lake. As completed in 1918, the Division Avenue Plant could pump, filter and deliver 15D m.g.d. into the Cleveland water system.42

Shortly after the turn of the century, the water at the intake crib serving the old Division Avenue Pumping Station became increasingly lower in quality, and as soon as the new 9-foot east side tunnel and the Kirtland Pumping Station on the east harbor shoreline were ready, Division Avenue was shutdown as a water pumping station and the tunnelsdiscontinued as a water supply source. Water from the tunnels did get used in the steam engines themselves which had been converted by Tom Johnson's Forest City Railway into an electric generating station for streetcar operation. The old Division Avenue facility served in this capacity probably until 1910, when the streetcar lines almalgamated into the Cleveland Railway Company.43

In 1913 plnas were being readied to extend the west side tunnels and enlarge the Division pumping capacity with a new engine house and additional engines of the huge triple-expansion type several of which had already been erected at Division, the new Kirtland east pumping station, and at Fairmount. Spring floods on the Cuyahoga River of that year affected the quality of the water supply so greatly that Mayor Newton D. Baker appointed a Filtration Commision to study the feasibility of adding a filtration plant to the proposed Division Avenue enlargement. In 1911 the city had begun chlorinating the water at the Kirtland Station, which was, at the time, supplying the whole system with water. No filtering of the water done.

Baker's five-member commission ran a series of tests on various filtering and water-softening processes in 1913-14, with the prior assumption that whatever process was selected would be some sort of mechanical filter device.44 A rapid sand filter experimental unit, of 50,000 gallons per day capacity, was built for committee's use. The water traveled through the unit in 2 1/2 hours, after being throughly mixed with chemicals. The committee heavily endorsed the rapid sand filter as the approoriate technology for any proposed filtration plant for Cleveland.45 Based on this recommendation, and with a growing typhoid death rate only partially solved by simple chlorination, the city added a large filtration plant to the plans for the enlargement of Division Avenue.

The new pumping station, located partially on the site of the 1874-1897 engine houses No.'s 2 & 3, and to the south of the original site of the 1856 engine house No. 1, rested on a foundation 16 feet deep within an outline of United States sheet steel piling driven by steam hammer 30 feet down. Concrete piles, inside the outline of the sheet piling, driven to bedrock, supported a 3-foot thick concrete matt under the engine mounts. Three of the triple expansion engines--one each of a Holly, Kilby and Allis--in place in engine houses 2 and 3, remained at the location, and the new building was erected around them.46

The progressive architecture of the engine house matched that of the new filter building going up to the east of it. A special wire-cut, multi-shaded brick and dark mortar produced a "pleasing effect" that lasts to this day. The roof was trussed and covered with a fire-proof sheathing and red Spanish clay tile. Across the front the building measures 285.5 feet with wings of 151 feet (north) and 117.2 (south). A boiler house wing on the east elevation measures 117' x 103' (approx.). Two chimneys of 9 feet internal diameter rose 228 feet above the ground (the top cornices have been removed, so they are somewhat shorter now).47 All ancillary buildings were built in the same style and with similar material.

Besides the leftover triple-expansion engines rebuilt onto the new concrete matt, the engine house was equipped with three more new engines of the same design and three steam turbine centrifugal pumps, which lifted the water our of the tunnel suction well and into the filtration plant. A fourth centrifugal added in 1920 pumped directly into the first high service district.48

As it stands in 1978, amid weeds and crumbling staircases leading to former neighborhood streets, Division Avenue retains much of its classic air. Although the last of the 6-story Allis-Chalmer triple-expansion pumping engies became scrap in early 1977, the floor space once occupied by them contains how the low-profile electric centrifugal pumps, sprawled across the floor. One DeLaval steam turbine in operating condition rests in the north wing, used but still hooked up to the original Stirling boiler plant. Those boilers still in operating condition in 1978 are used solely for heating the building. The boiler house and the huge boilers and coal-stokers are due to be replaced with a smaller structure and more-efficient heating furnace equipment. Huge wrenches and tools of a scale only applicable to a six-story steam-breathing machine hang still on the walls of the engine house, as a reminder of past back-breaking service calls.

In the main engine room, and the north wing, traveling cranes still play the airspace over the engine wells. Both Cleveland-Crane products, the main room has a crane of 25-ton capacity, and the low-lift pump room one of 10-ton capacity.

The six original Stirling water tube boilers and the retort mechanical stokers sit quietly in the boiler house even today. Overhead, storage bins holding 1080 tons of coal feed the stokers by gravity, through automatic weighing hoppers, and are fed themselves by two Link-Belt conveyors which double as an ash-removal system when not loading coal into the bins. Coal still fills the hoppers, and the mechanical stokers, run by water pressure, can still be used to feed coal into the furnaces. The complete boiler house installation exists as built only there are no longer steam engines gasping for the energetic vapor that is the boiler room's sole product. As a heating plant, the boilers are mismatched to the function and face definite replacement with smaller furnaces designed to heat the building. The boiler room itself may became victim of the demise of the boilers, unless adaptive use of the building can be justified. Economically it may prove easier to tear down the whole structure, than to remove the boilers and stokers piecemeal.49

A description of the pumping station, after the engines has been turning and pumping for over three years, realistically praised the new facility:

> After conditions in the station are not ideal. If the station were rebuilt now, some changes would certainly be made, but at the same time it is felt that it is a very efficient station, which will do good work for many years to come.50

The Filtration plant arose with the new pumping station and just to the east of it. As with the engine house, the filtration building retains its architectural flavor, having been built in a style and with materials to match its neighbor buildings. In contrast to the pumping station, the filter building retains its interior space and equipment much in the same form as built. Few major changes have been made, and those that have, such as replacement of the roof, blend in very well with the original work. Given the early history of Division Filtration, it is a complete wonder that it is extant at all, let alone daily filtering a large per centage of the Cleveland system's drinking water.

Work on the filter plant began in May of 1914. A large area to the east of the new pump station between the Old River Bed and Buckley Boulevard was excavated for the filter basins, the coagulating basins and the mixing chambers.51 The excavation and the pouring of concrete was facilitated by two cableways spanning 730 feet across the site, stretching between four towers running on double railway tracks. This cableway, a major installation in itself, not only removed dirt and brought in concrete, but moved other major equipment around the construction site. A concrete mixing plant, erected on the site of the 1856 power house, supplied the 5-yard capacity buckets of the cableway via a conveyor belt and 3-foot guage railroad. Electric lights along a smaller, third cableway allowed nighttime work. The walls of the basins were poured using reusable, interchangeable wooden forms produced on site. In one ten hour period as much as 1200 cu. yd. of concrete were poured, and the maximum for one 24-hour period being 1620.52

The large coagulating basins (where the impurities clumped together before filtering) measured 850' x 250' and about 20' deep. The mixing chambers are 650' x 85'. The floor of the coagulating basin and the filtered water reservoir were poured as groined arches, inverted. The mixing chambers were flat-floored and baffled.

A brick building with clay tile roof covered the 36 rapid sand filters. This one-story filter building, 733 feet long and 50 feet 9 inches wide, had two wings with 18 filters in each, and a 75' x 75' (approx.) administration building in the center, which had two stories and contained offices and testing laboratories.53

Soon after completion of the construction, but before the plant was put into operation, serious problems began to arise that would delay the opening of the plant for almost two years. The new facility was said to present "....the picture of a remarkably extensive foundation failure...."54 Settling as the ends of the long coagulating basins reached 6" to one foot during 1916. The plant had begun to fall apart as soon as it was finished. The cause of this major failure lay in the construction of the whole structure on a concrete slab which was "floated" on the unstable clay and sand (quicksand) along the banks of the Old River Bed. Although the pumping station had been built on piles driven over 40 feet down to hard bedrock (necessary because of the huge weight of the engine), and although the U.S. Army Corps of Engineers had been building extensively along the lake bed for many years, and the water department itslef had tunneled through the layers in the area, --apparently in spite of much previous example and knowledge--the new filter installation did not rest on any foundation piles. The result was that the filtered water reservoir and the coagulating basins were so cracked from settling that they were unusable. Once such basin, the most westerly coagulating basin, has never held water and remains unusued even today.55 Likewise, the effluent conduits leading from the filters had to be replaced by closed pipes which were run through the original open conduits which were changed to simple dry access shafts for the pipes.

When a section of roof of the west basin of the new 25,000,000 gallon filtered water reservoir collaposed on July 9, 1916, three consulting engineets (one Clevelander and two non-Clevelanders) formed an investigating committee in the water department. Their examination of the nature of the foundation floating on layers of quicksand and peat led to considerable repair work over the eight years.

Immediately, one of the consultants, N.C. Johnston of New York, drew up plans for the relining and rejacketing of the totally unusable filtered water reservoir. This work began in early 1917 and finished before the year ended. Other work begun in 1917 included the removal of all backfill from the foundation of the west end of the filter galleries, and the removal of the brick superstructrure of the filter building over that end. Holes were cut through the reinforced concrete of the cracked effluent galleries, and piles (of steel pipe and concrete) were driven to bedrock and the foundation structure of the concrete galleries rebuilt upon them. As started before, the open effluent conduits were converted to dry causeways through which a 48" steel pipe line in 1917, and the plant opened in 1918 with a wooden shed covering the west end of the filter building.

In 1921-23, further reinforcement of the foundation using piles driven through holes in the original foundation, as in 1917, was completed. In 1924-25 the filter building section razed in 1917 was finally replaced, and sheet steel piling driven along the north, east, and west sides of the filter building to a depth of 5 feet into the stiff clay under the quicksand, was to prevent the whole structure from sliding into the river to the north.56 So far everything has held together.

Settling problems were not the only ones affecting the new facility. Plans to soften the water, as well as chlorinate. ammoniate and filter it, were subverted by the inadequacy and poor begin of the lime, handling equipmemt in the chemeical house.

The mixing chambers, through which the water flowed and churned after the chemicals were added, and been designed with 144 baffles along its 650 foot length to promote mixing. Water was to flow at a rate of 60 ft/min. It was found, however, that with all these baffles in place the water would hardly flow at all, and 108 of them were finally removed. With all the baffles in place working parameters could not be determined, but the final operating figures, with the remaining 36 baffles, showed a water movement at 20 ft/min and a loss of head (or pressure) of a respectable 3 feet.57

In its final form, Division Avenue Station and Filtration Plant processed water through a succession of operations: pumped up from the lake through the new 10-foot, and older 5 and 7 foot, tunnels, water entered a 30-foot diameter screen well where large objects were removed before the suction wells for the pumping engines. Running by gravity into the suction wells, the water was lifted into the filtration plant by the centrifugal pumps in the north wing of the engine house, flowing through a 72" riveted steel pipe into the chemical house. Chlorine, ammonia and alum were added to the raw lake water, which then flowed slowly through the baffled mixing chambers. From there the water spent the next several hours in transit through the coagulating basins. Here impurities settled to the bottom or rose to the top of form flocculus or "floc," floating clumps of impurities catalyzed by the alum. Passing through the sand filters, the sand and gravel removing the "floc," the water became purified into its final form, and flowed then into the filtered water reservoir. Of only 25,000,000 gallon capacity, the reservoir was really the suction well for the hugh rotary-crack-piston triple expansion engines that pumped the water directly into the system. A small portion of the water, 450,000 gallons, remained at the plant in a wash-water reservoir, and could be forced backwards through the filters to cleanse them of the build-up of impurities.58

Except for the substitution of electric centrifugal pumps for the steam driven turbine and rotary-piston pumps, the present operation at Division does not differ from the original sequence in any significant way.

The final rehabilitation of Division in 1925 coincided with the completion and opening of the Baldwin Filtration Plant and Reservoir complex on the city's east side, and marked the first year that all of Greater Cleveland served by the Water Department of the City of Cleveland received chlorinated-filtered water. It also gave the system, for the first time, an east-west balanced, duplicate system. The beginnings of Division's east side mirror-image system rest with the construction of the nine-foot diameter lake intake tunnel and intake crib No. 3 at the end of the nineteenth century.

III BALDWIN FILTRATION PLANT & RESERVOIR AND THE EAST SIOE WATER SUPPLY SYSTEM

In 1896, the Cleveland water supply system was taking water from Lake Erie, at a point a little more than a mile from shore beyond the west harbor area, and pumping it directly, untreated in any way, to its west side residents, and also to the east side residents via the Fairmount Reservoir and re-pumping station, and the reservoir on Kinsman Road. The demands on this system were great, and the quality of water at the old intake crib had decreased greatly. That same year the east side lake tunnel and the Kritland Street Pumping Station on the east harbor shore construction projects were started, but not until 1904 did they begin supplying water to the citizens of Cleveland.

The new lake tunnel, 9 feet in diameter, ran from the east shore 26,000 feet, at an angle, to a new intake crib about 4 miles directly opposit the harbor entrance and mouth of the Cuyahoga.59 The cirb, known as intake Crib No. 3, and the tunnel serve the water system in 1978. Crib No. 3 is the sole remaining visible intake crib; all others have been converted to or built as submerged structures.

Built in 1898-99, the crib sits in 50 feet of water, and rises almost as much above the water. The outside diameter of the steel well-like structure measures 100 feet with an internal well of 50' diameter. A two-story-plus-light-tower structure rests on the crib, its floor about 20 feet above water level. Originally manned by a two-person crew who operated warning lights and fog whistles, the crib works automatically now, and is home only for spiders carried over in earlier days.

Water enters the lake shaft of the nine-foot tunnel through twelve inlets around the circumference of the crib, each 6' x 7'. The ratio of inlet area to tunnel area was purposely kept high (8:1) to keep the influx velocity low to prevent ice from being swept into and through the ports and clogging the inlets or tunnel itself.60

On a clear day the red-rimmed crib shows clearly from all along the Cleveland Shore, and is visible even in relatively poor weather. It serves as a fairly good indicator of air clarity.

The tunnel which sucks the lake water through this intake presented a host of serious problems, taking almost with years to build. In 1901 fifteen workmen died in a single week in accidents around crib No. 3 and a temporary construction crib No. 2.

On August 14, the temporary crib along the line of the tunnel about 19,000 feet from shore, caught fire and burned to within 13" of the water. Burned to death were five workmen, another four drowned trying to escape, and still another man died in an attempt to save the others.

A separate incident involved the pressurized tunnel entance. The tunnel had been pressurized to keep leakage into the unfinished brickwork at a minimum, and access shafts were provided with double pressure locks. On August 20, such an access shaft at crib No. 3 broke off at the lake bottom and shot up into the crib, partially filling with water at the same time. Five men drowned in this single accident.61

The tunnel, a 3-concentric-ring structure, upon inspection in 1902 revealed a series of defective work, a result of the combination of contract price, time schedules and continual delays because of loose sand, clay and pockets of gas, as had plagued west side tunnel construction. However, the nature of the poor work in the east side tunnel made the previous work on the other side of town look like a masterpiece of supervision and handiwork. The 1902 inspection revealed:

1) a 7,200' section completely blocked by sand filling in the tunnel through the brickwork;

2) a 10,500' section very similar to that of the first;

3) 130 test holes to inspect the brickwork found that the third (outside) ring was completely missing in places; bricks had been simply tossed into place in other sections; and that in some areas none of the three rings were held together with mortar, but the bricks simply shoved together;

4) of all this work, however, only 400' of one section lacking an outer ring of bricks needed complete replacement.

These problems were compounded when the tunnel was depressurized and sand and gas began seeping in.62 The tunnel was not ready for use until 1904, from which time until the opening of the Division Plant in 1917-18 it carried the whole water supply for the city.

A new pumping station, on the lake shore at the foot of Kirtland Street (E. 49th) was ready to use the new tunnel in 1904. Equipped with two Holly triple-expansion steam engines, the station's capacity equaled that of Division at the time (50 m.g.d.). The station pumped raw lake water into the system until 1911, when in September chlorine of lime was added to the water to combat the bacteria in the water which had been causing typhoid deaths in Cleveland at an increasing rate, as the solid waste content of the lake water became greater as the Cuyahoga River became more polluted. In 1917 Wallace & Tierman liquid chlorine machines were installed. Chlorine is still applied to the Cleveland water in liquid form in 1978. The water, however, in 1911 was not filtered nor was there odor control of any kind.63

In 1908, after the opening of Kirtland pumping station, 30 acres of land was acquired in the second high service district to the south and east, just above the older Fairmount reservoir and pumping station, for the establishment of a large reservoir to handle the incresed flow of water which the new tunnel allowed. Excavation began in the winter of 1914-15 with the removal of top-soil "by direct labor, the sole purpose of which was to provide work for the unemployed at that time".64 Excavation through the underlying shale rock began on May 24, 1915, by a local excavation company under contract to the water department.

The excavation work required the laying of a ballasted railroad with 75-80 lb. rails, a 120-ton Bucyrus digger crane, 30-yd. capacity dumper cars and 3 locomotives to haul equipment and rock. This initial digging, except for the final trimming which had to be left for a later time since shale rock disintegrates when exposed to the air, was complete in 1920.65

In that same year a special consulting commission issued a report on the enlargement of the Cleveland water system that endorsed the reservoir site as also a suitable location for a second filtration plant, an east side counterpart to the newly opened Division Avenue Filtration. The east side filtration plant had been planned for the Kirtland Pumping Station, but the soil there was of the same sandy, insubstantial character as at Division and promised the same problems of settling and expensive foundation work.66 The reservoir site on Baldwin road offered a solid-rock foundation, and a reservoir-filtration complex which was nearly as ideal as a pumping station-filtration combination. The old Fairmount re-pumping station was just to the north and could be revamped.

In 1920, with the basic hole for the reservoir dug, the construction facilities were altered to include an 11 acre filtration plant with the 13 acre covered reservoir. A construction plant similar to that used at Division spanned the Baldwin site in the early 20's. A single Ledgerwood cableway with electric motors, running on a five-rail track on either side, carried a 7 cu. yd. bottom dump concrete bucket, and was controlled by one operator. The concrete mixing plant was just north of the proposed coagulating basins. A temporary service railroad allowed the contractor to supply and service both the cableway and mixing plant.67

The pouring of concrete, the building of the filters, coagulating basins, mixing basins and conduits went without problems, and the whole complex was finished and put into full operation in October, 1925.

The design of the filter building at Baldwin is similar to that at Division. An administration building is flanked by two wings to filter galleries, and is a skeletion steel structure with brick facing and stone veneer, with a graduate slate roof. A stone double stairway leading to the main entrance covers the pump room for the filter wash-water apparatus. The wash-water tanks are on the upper floor of the building, on steel grillage, and have a capacity of 423,000 gallons.

The sections of the building covering the filters themselves are reinforced concrete with stone veneer. The roof over the center gallery between the two rows of filters is supported by a steel turss, but the roof directly over the filters in lower, a concrete slab on a concrete beam. The exterior roof is also graduates slate. An exterior walkway around the filter building rest on top of the concrete slab roof over the filters, at the level of the upper story of the administration building, with walk-through porticos halfway along the length of the gallery wings.

The flow of water through the chemical house, coagulating basins and filters to the filtered water reservoir is basically the same as that of Division, except that the old Fairmount reservoir now serves only as a holding tank of raw lake water for the filtration plant, and the chlorination of the water at Kirtland station was stopped. Branch mains leading off the pipes from Kirtland to Fairmount were sealed closed, and raw lake water once more crossed Cleveland's east side.68

Alum, the coagulant, was added to the rae water at the chemical house and mixed through the turbulence of hydraulic jump mixing flumes located in the same building. From there the water spent about 4 hours and 40 minutes slowly making its way through the coagulating basins just to the south of the main reservior. These basins, with a capacity of over 8,000,000 gallons and average depth of about 15 feet, measure 110' x 662' (approx.). Here the impurities in the water clump together to increase the efficiency of the filtering system.

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The sand filters measure 33.5' x 49' (interior) with an area of 1450 sq. ft. The sand and gravel material lay in the filter in five layers: 4 of graded gravel (22" total) and a 30" layer of sand. Water runs down onto the filters from 2 1/2 cast iron pipe with 11/32" diameter holes spaced on 4 1/4" centers.

The same process and equipment serves to treat Cleveland's drinking water in 1978. From the filters the water flows via concrete conduits into either or both of the two halves of the massive filtered water reservoir.69

Two parts of the Baldwin facility differed markedly from Division: the size of the filtered water reservoir and the method of mixing chemicals into the raw lake water.

Baldwin reservoir, when built, was the largest covered reservoir in the world. measuring 100' x 521' (interior), with a depth of 36'. A dividing wall actually separates the structure into two independent reservoirs, 504' x 521' each. The concrete roof of groined arches rests on 1196 clumns, each 30" in diameter, 34'3" tall called an architectural masterpiece because of the sense of space which was created by the forest of columns and groined arches. Likened to a Gothic church by those who were priveledged to view it before the waters flooded into it in 1925, the reservoir conveyed a sense of "simplicity and purity" while at the same time it existed as an abstraction:

> It is the work of a law, of a formula ruling over space and mass--rather, perhaps a law brought into the range of our feelings by being stated in the most fundamental, most simple terms of human need for formal perfection. It is the product of man's desire for order freed from the old conventions of architecture by the new conventions of engineering.71

This hall of columns holds 135,000,000 gallons of filtered water to this day, and is still the major filtered water reservoir in the Cleveland system, serving the low level service district (including downtown Cleveland) by gravity only, and the high service areas through the Fairmount repumping station, which was built in 1924 alongside the old station.

Aside from Baldwin's impressive appearance, and the obvious quality of concrete work, although some cosmetic and a little structural deterioration is present (especially on the exterior of the chemical house), the most interesting aspect of Baldwin are the mixing chambers of a design devises and patented by Joseph Ellms, engineer in the Cleveland water system. Called hydraulic jumps, or hydraulic mixing flumes, these visible sections of purposefully turbulent water in the chemical house across the main reservoir from the filter building, are the most innovative part of Baldwin Filtration.

In his patent for an "Apparatus for Water Purification" Joseph Ellms defined a hydraulic jump:

> ...when a sheet of rapidly moving water strikes a body of water which is either standing still or moving with a lower velocity, the kinetic energy of the miving stream is very largely dissipated in the form of countless eddies and whirlpools accompanied by the entrainment of large quantities of air which seethe and bubble to the surface, the standing water being also elevated just below the point of impact to a height above the level of either the inrushing or the outflowing stream.72

Ellm's patent covered, in essence, a naturally occuring phenomenon of one body of water running into another. In most cases, in irrigation canals or at the base of water falls, such jumps of turbulent water simply dissipate the kinetic energy of the water and produced only sources of water flow problems. Ellms determined that such energy might be put to good use in mixing chemicals into water. His patent, is reality, covered the controlled production of such jumps through the use of inclined planes and the application of these jumps to mixing. The hydraulic jump not only mixes through turbulence, but also aerates the water, eliminates the need for baffled chambers, and mixes small amounts of chemicals into large volumes of water very well.73

Prior to installation at Baldwin, a large scale experimental mixing flume was set up at Kirtland Pumping Station where the characteristics of the jump for mixing and the appicability to large filtration plants were recorded.74

As installed at Baldwin Filtration chemical house, water enters the hydraulic jumps from a rising well which lifts the water 28 1/2' feet to a large horizontal pool 70 feet across. This pool leads to three expanding flumes where the jump occurs. The entrance to these flumes have curved entrances (abuttments of 5' radius). The throat of each jump is 10 feet wide and 11'1" long, expanding to a 22' width and dropping 3 feet within a lateral distance of another

10 feet. The jump is produced along, near the base of, the drop. The water enters into another 70' wide common flume, which converges to 30' in a distance of 58 feet. A straight, level flume of 30' width, divided into a 19' wide conduit. Here, in the divided flume, are the weir planks which control the elevation of the water in the converging flume back at the base of the expanding flumes, and so controlling, ultimately, the location of the hydraulic jump (See HAER). The conduit leads to the coagulation basins. This design was based directly on the experiments performed at Kirtland Pumping Station.75 The jumps are visible from an operating gallery (see HAER S24BF and P95BF) in the chemical house, and in fact must be visible to allow regulation of the location of the jump along the flume.

As completed in 1925, the Baldwin complex cost the city of Cleveland (not including land and landscaping) a total of almost $9,000,000.

The experimental equipment at Kirtland in the design investigations for the hydraulic jumps did not represent the system's only experimental venture. In the years 1928 to 1936, both at Division and at Baldwin filtration plants, large scale water treatment experiments were conducted on, principally, the control of odors through dechlorination and ammoniation.

In 1929-30, at both filtration plants, ammonia in liquid form was introduced directly into the water supply to test its effect as a taste-and-bacterial-control agent when combined with chlorination of the water, a process in use since 1911 in Cleveland.

At Division the ammonia was added to the filtered water just before the chlorine, at a rate of 2 lbs. per million gallons of water for the first six months. After that, the dosage of ammonia dropped to 1 lb. per million gallons. At the same time, 3 to 4 lbs. of chlorine was being added to the same amount of water.

The Baldwin experiments varied conditions more often during the test run, adding ammonia in the amounts of 0.5 to 2 lbs. per million gallons, and 2 to 5 lbs. of chlorine. During the months April, June and October of 1930 no ammonia was added as a control test period.

The results of the tests became available in early 1931. The ammonia successfully controlled the chlorine and other tastes in the water, and sterilization was quick and highly satisfactory. Chlorine, at a solution of 0.1 parts per million in the water was found to prevent bacterial and algae aftergrowth and the addition of ammonia aa a taste control had no effect on the anti-bacterial action of the chlorine. The introduction of ammonia increased the treatment cost per million gallons of water from 22¢ to 34¢, a significant increase of 54.5%, which prohibited wide scale use of ammonia in the system.76

In 1928 and 1936, at Baldwin, more tests were runn on odor control testing this time two possibilities: ammonia (again) and granular activated carbon. Over 5,000 samples were collected in 13,500 tests involving 15,000,000 gallons of water. Three large wooden tanks with interconnecting pipes and valves, and Wallace and Tierman chlorinators, allowed a wide range of flow parameters in the 1928 tests which focused mainly on the suitability of a 24" tile carbon filter. The 1936 tests were run on a large unit allowing 24-hour operation, and complete simulation of conditions at either Baldwin or Division or even parallel tests simulating both.77 The 1928 wooden vats and some associated valving and piping rests still in the lower floor of the Baldwin administration building. The tests on activated carbon proved fruitful, and this the material used today, especially in the hot summer months to control odors in the lake water originating from the higher algae counts.

Next to the introduction of new chemicals into the drinking water, and the installation of new pumps, tunnels, reservoirs, filters and water mains, the most dramatic change in the Cleveland water system undoubtably occured in the years 1901-1909. Daily water usage per capita had increased in the decade 1890-1900 from 100.8 to 171.3 gallons-an increase of 70% The reasons for this were an increase in household water usage and the fact the less that 5% of the users of the water were being metered. A flat rate of charge, independent of amount of water consumed, was applied to all residential users and most large commerical users. In 1902 the city began installing meter and charging the consumer by the actual amount of water consumed, in all residential and commerical hood-ups. This resulted in a decrease in the daily per capita water consumption in the first decade of the twentieth century from 172.2 to 97.8 gallons--below the 1890 level. This represented a drop of 43%. Total consumption actually decreased as the rate of decrease in the water usage exceeded the rate of increase in population and industrial growth combined.

This ten year period of negative growth in the water system was reflected on a delayed basis in the building program, during the years 1904 to 1914, between the completion of the Kirtland-9 foot tunnel and the start of construction on Division. The savings to the system were substantial. Metering costs to the end of 1909 reached $1,288,000 but were justified against the cost of additional facilities which would have been needed given the same rate of increase in usage experienced at the end of the 19th century. The real savings were estimated at about $800,000 over the ten year period, though considering the growth of the system after this period, in 1910-1920, even with a 100% metered system, this estimate appears to have been highly conservative.78

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IV SUMMARY

The Baldwin and Division Plants represent expansion of the Cleveland water system after the introduction of water meters, and after the readjustment of the negative growth rate of the decade 1901-1909. The technology of the two plants, especially the filtering and reservoir systems, was such that the existing facilities have resisted major changes. Even considering the structural instability of Division, the two plants exist and operate today much as they did in 1981 and 1925.

The pumping station at Division remains architecturally the same as when it was first put into operation, but all steam powered pumps have been replaced on the lines by electrically powered centrifugal turbines.79 The new pumps are cheaper and easier maintain and run (relatively and actually), though they also create a dependence on the electric utility which had never been the case when the station produced its own pwoer directly from the burning of coal. The nre pumps also disrupt the scale of the old engine house. At best reaching half-way up the bottom of the floor wells of the old engines, the new pumps leave the several story engine room air space as a disturbing vacumm of form that seems to demand that something bulky ought to be taking all up that room. Eventually, this discontinuity of space in the old building will suggest its replacement, as at Kirtland, with a new, low-profile pump facility designed specifically for the newer pumps. Such a replacement has already been recommended for the boiler room wing. All of Division may be scheduled for replacement if and when the city of Cleveland solves its financial problems or when the water system gets transferred to a regional governmental body.

Baldwin, because of its excellent operating condition, will serve the system easily for another 25 years.

The eventually future of these facilities, as historical sites, presents an intriguing value judgement for the historian and/or preservationist. Although both represent state-of-the-art water treatment technology for their respective time periods, and architecturally classic brick and stone public works projects, and even though Baldwin has several important features which are innovative, they are both, nevertheless, crucial elements of a system of which the sole purpose must be to supply the citizens of Greater Cleveland with clean and potable water. Should the replacement of either site be questioned, the ultinate answer rests on the system's physical ability to supply water. The engine house at Division Avenue is already a Cleveland landmark. Whether the other structures at Division Avenue and Baldwin Fairmount ought to be nominated as National Landmarks can only be answered by the same value-charged consideration: how can the water system best perform its function, the supply of water. The historical important of both sites rests solely on their function of water treatment for the people. If they can fulfill that function in any way, either by continued service or through surrender to the wrecking ball, then that, in the end, ought to be the guideline whereby their futures are determined.

NOTES

1. Thomas J. Brazaitis, "Cleveland on the Brink: Time, Political Tides Undermine Water System," Cleveland Plain Dealer, August 1, 1978, pp. 8A.

2. Theodore Scowden, Report to the Common Council of the City of Cleveland, on the Subject of Water Works, for Supplying Pure and Wholesome Water to the Inabitants, accompanied with General Plans for Carrying the Project into Practice; together with a Supplementary Report Suggestive of a Thorough System of Sewerage in Connection with Water Works, Cleveland: J.W. Gray & Spear, Plain Oealer Office, 1853), p. 5.

3. Cleveland Water System, (City of Cleveland, 1924), p. 4, estimated that the lake held 17,500,000 million gallons. The Cleveland Water Story (City of Cleveland, n.d. (1970))estimated 132,000 billion. The point being made in either case was that a practically inexhaustible supply of water lay at Cleveland's doorstep.

4. Cleveland Water System (1924), pp. 4-5.

5. Benhu Johnson, a veteran of the war of 1812, supplied water from the lake at a charge of 25¢ per two barrels. James Kennedy, A History of the City of Cleveland: Its Settlement, Rise and Progress 1796-1896., (Cleveland: The Imperial Press, 1896), p. 155.

6. Ibid., p. 275.

7. Ibid., 246; J. Whitelaw "The Cleveland Water Supply," Engineering News 6 (1879): p. 132. The 1850 amendment gave the company the exclusive right to supply water for the whole city. Capital stock was allowed to increase to $200,000, but only $27,000 was rasied Officers were elected on May 4, 1850 and the company disappeared shortly thereafter.

8. William G. Rose, Cleveland: The Making of a City (Cleveland: World Publishing, 1950), pp. 133, p. 197.

9. Kennedy, pp. 365-366.

10. Whitelaw, p. 132.

11. Kennedy, p. 355.

12. In 1975 an executive order of the commissioner required that all utilities offices clean their files for future growth and adequate record keeping. At that time all engineering drawings of temorary construction facilities and non-existant or obsolete sites and equipment were pulled from the files and destroyed. Four drawings from the nineteeth century escaped the process. Two, of the Cornish pumping engines of 1856, hand today under glass in the office of the head of pumping for the water department. Two, of the original city reservoir, have been given to the Western Reserve Historical Society in 1978. No attempt was made to contact the historical society in regard to the drawing, although a large collection of glàss photographic negatives was donated at the time to the historical society.

13. Scowden (1853), p. 14.

14. Whitelaw, p. 132.

15. Scowden (1853), p. 5.

16. Theodore Scowden, "Engineer's Report upon the Character, Capacity and Cost of Cleveland Waters Work," Report of the Trustees of Works to the City Council of the City of Cleveland for the Year 1856 (Cleveland, 1857), p. 13.

17. "An Accident to a Faithful Servant," Engineering Record 42 (1900): 612. The drawings of the engine, on the back, list the same of Frederick Saunders as the engineer in charge at the Allaire Works.

18. Theodore Scowden, Third Report to the Trustees of Water Works of the City of Cleveland (Cleveland, 1855), p. 6.

19. Scowden, "Engineer's Report..." (1857), p. 10. The engine weighed about 20o tons each.

20. "An accident to a Faithful Servant," p. 612. This information had been supplied to the Engineering Record by W.W. Kingsley, Superintendent of the Cleveland Water Works.

21. Scowden, "Engineer's Report..." (1857), pp. 10-11.

22. "Report of the Superintendent and Engineer," Report of the Trustees of Water Works to the City Council of the City of Cleveland for the Year 1862 (Cleveland, 1863), pp. 7-8. Same complaint was reported in the next year's (1863) report, 7.

23. Ibid.; ...for the Year 1871, pp. 2, 19; ...for the Year 1874, p. 9.

24. Whitelaw, pp. 185-186, gives comparative performance data for Cornish and Duplex engines. The major difference seemed to lay in the amount of coal consumed in getting up steam in the Cornish engines.

25. "Report of the Superintendent and Engineer," ...for the Year 1884 (Cleveland, 1885), p. 39.

26. Ibid., ...for the Year 1885 (Cleveland, 1886), pp. 21-22.

27. C.F. Schulz, "The Development of the Water System of Cleveland", Journal of the Cleveland Engineering Society 9 (1916): p. 138.

28. Scowden (1853), p. 7.

29. Scowden (1855), p. 11; Report of the Trustees (1857), p. 11.

30. Rose, p. 278, has a full view of residents climbing the stairs and walking on the reservoir walkway.

31. 30th Annual Report of the Water Works Department for the Year 1885, p. 22; 31st Annual Report...1886, p. 25; 35th Annual Report...1890, p. 10; Howell Wright, "Cleveland's Water Supply Problem", Cleveland Engineering 20 (1928)" p. 4.

32. Schulz, p. 125; Cleveland Water System (1924), p. 5; E.E. Buchanan & Joseph W. Ellms, "A Brief History of the Cleveland Water Supply", Cleveland Water Department, 1936, p. 1. (Typewritten.)

33. Report of the Board of Trustees...for the Year 1874, p. 17.

34. J.N.H. Christman, "The Division Pumping Station at Cleveland Ohio and Its Operation", Journal of the American Water Works Association 8 (1921): p. 434.

35. Report of the Board of Trustees...1874, pp. 37-38; Whitelaw, pp. 140-144. As late as 1930, Lake Erie water was praised for its quality when unpolluted by the river. Joseph W. Ellms, "The Problem of Water Purification and Sewage Disposal on the Great Lakes", American Association for the Advancement of Science, paper presented at Cleveland meeting, December 29, 1930.

36. Report of the Board of Trustee...1874, pp. 25, 27.

37. Ibid., p. 33.

38. Ibid., pp. 28-30, 32.

39. Ibid., p. 36.

40. Schulz, pp. 126, 146; Buchanan & Ellms. p. 1.

41. See maps in Cleveland's Municipally Owned Public Utilities: Water Supply, Sewage Disposal, Electric Light and Power (City of Cleveland, 1937), p. 2, and The Cleveland Water Story 1970, center two pages, n.p.

42. Schulz, p. 129.

43. Ibid., p. 133.

44. Hippolyte Gruener, "Water Filtration and Softening Tests at Cleveland, Ohio", Engineering News 72 (1914): p. 480. Gruener, professor of chemistry at Western Reserve University, Cleveland, was a member of the Filtration Committee. Also on the committee were A.W. Smith, professor of chemistry, Case School of Applied Science, Cleveland; R. Winthrop Pratt, consulting engineer, Cleveland; Dr. Willaim Miller, Ohio State Board of Health; and D.G. Perkins, City Bacteriogist and professor of hygiene and preventive medicine, Western Reserve Medical School, Cleveland.

45. Ibid., p. 480. A "rapid" sand filter as opposed to a "slow" sand filter simply refers to the length of time the water is detained in the filter.

46. "Construction Plant for Cleveland Filters", Engineering Record 70 (1914): 506; S.C. Simmermacher, "Progress in Pumps and Pumping Station", Journal of the American Water Works Association 35 (1943): p. 883; drawing F-1103, "Water Flow Diagram for West Side Tunnels, Division Pumping Station and Filtration Plant", Utilities Engineering, City of Cleveland (HAER); Cleveland Water System (1924), p. 7; Schulz, p. 144; Christman, p. 437. A collection of 8' x 10" glass photographic negatives of the Cleveland Water Department dating principally 1912 - 1932, contains a complete photographic record of the construction sites at Division Avenue and at the later Baldwin site. This collection of approximately 4,000 negatives, given to the Western Reserve Historical Soceity in 1975, has only a cursory index and is, therefore still very unwiedly for research purposes. All the negatives however have sequential numbers, and some have dates and legends. The collection is an invaluable source for information on the construction of large public works projects in early 20th century America.

47. "Cleveland Water Supply to be Purified and Softened", Engineering News 76 (1916): 735; Schulz, p. 141. The dimensions were altered slightly from an earlier plan which called for a T shape 226' x 73' with a single wing 148' x 52' and boiler house meauring 100' c 96'. Christman, p. 437.

48. Christman, p. 440; Simmermacher, p. 383; Schulz, p. 144. The three older engines were triple-expansion rotary-crank-piston varieties, and had cost the following: Holloy (1901) - $115,700; Kilby (1897) - $131,500; Allis-Chalmers engines cost $84,500 and $90,000.

49. Schulz, p. 145; Christman, p. 437.

50. Christman, p. 441

51. Drawing L-141, "Filtration Plant at Division Pumping Station", 1914, Utilities Engineering, City of Cleveland (HAER   ) gives an excellent schematic of the site with construction apparatus.

52. "Construction Plant for Cleveland Filters", pp. 504-505.

53. "Cleveland Water Supply to be Purified and Softened", p. 735; drawing L-141 (HAER   ).

54. "serious Settlement Destroys Part of New Filter Plant", Engineering News 76 (1916): p. 1101.

55. Ibid., Greater Cleveland Water Supply System Development Plan (1972), Urban System Engineering Demonstration Grant, HUD Contract Project No. OHIO-USE-1, Contract No. h-1079, p, III-8.

56. Wendell Brown and James Herron", The Rehabilitation of the Division Filtration Plant", Cleveland Engineering 19 (1927): 5-9.

57. Joseph Ellms, "Operating and Tuning Up of the Cleveland Filters", Engineering News-Record 88 (1922): p. 776.

58. Schulz, pp. 141-143. Impurities washed out of the filters are still simply returned to the lake untreated in any way.

59. "New Water Works Intake Tunnel for Cleveland", Engineering News 50 (1898): p. 82-84, illustrations, 6 figures, Supplement, August 11, 1898, n.p.

60. Schulz, p. 130, includes photogrpah of crib No. 3.

61. "The Accidents at the East Side Water Works Intake Tunnel, Cleveland Ohio", Engineering News 46 (1901): 183-139, with a diagram of the events of the accident.

62. "Defective Work in the Cleveland Water Works Intake Tunnel", Engineering Record 47 (1903): p. 552, with illustrations.

63. Cleveland Water System (1924), p. 12; Charles Goffing, "Kirtland Street Pumping Station of the Cleveland Water Works", Engineering Record 49 (1904): p. 348-51.

64. "Excavation for the Baldwin Reservoir, Cleveland", Engineering News-Record 75 (1916): p. 838.

65. J.W. Ellms, A.G. Levy, G.W. Hamlin, and J.E.A. Linders, "Baldwin Filtration Plant, Cleveland, Ohio", Cleveland Division of Water, City of Cleveland, n.d., p. (Typewritten.) This 88-page, well-written, and detailed description of the Baldwin facility (probably written about 1925-27) was apparently never published, and may have been written for the A.S.C.E. It is without a doubt the finest piece of documentary material used in the 1978 HAER survey.

66. A.G. Levy, "A Quarter Century of Development in Cleveland's WAter System: General Development of the System," Journal of American Water Works Association 35 (1943): 469; Ellms, et al, "Baldwin," pp. 3-4.

67. Drawing L-784, "Baldwin Filtration Plant General Plan", Utilities Engineering, City of Cleveland, 1923 (HAER).

68. L.A. Marshall, "The Baldwin Filtration Plant", Journal of the American Water Works Association 35 (1943): 888, contains a simple line drawing of filtration plant and reservoir.

69. G.W. Hamlin, "The Baldwin Filtration Plant", Journal of the American Water Works Association 17 (1927): 421-427.

70. Ibid., p. 427.

71. Elbert Peets, "The Cleveland Reservoir", Journal of the American Water Works Association 17 (1927): p. 419. Peets was an architect whole three page expression of love and admiration for the new Baldwin reservoir is itself a masterpiece of expression of the engineering aesthetic. The article was originally published in the Nation, February 9, 1927.

72. U.S. Patent No. 1 1,362,611, p. 1.

73. A.G. Levy & J.W. Ellms, "The Hydraulic Jump as a Mixing Device", Journal of the American Water Works Association 17 (1927): 2, 6; Ellms' U.S. Patent, p. 2.

74. Levy & Ellms' pp. 2-5 Figures 1 & 2, pp. 4-5, in this article show respectively a schematic of the basic hydraulic jump and the wooden flume device used in the experiments.

75. Ellms, et al, "Baldwin," p. 16; Levy & Ellms, pp. 2-3.

76. W. C. Lawrence, "The Ammonia-Chlorine Treatment at Cleveland", Journal of the American Water Works Association 23 (1931): 1382-1387; Matthew Braidech, "The Ammonia-Chlorine Process as a Means for Taste Prevention and Effective Sterilization", Ohio Conference on Water Pufification 9 (1930): 67.

77. W.D. Lawrence & Matthew Braidench, "Cleveland's Experimental Pilot Plant at Baldwin Filters", Water Works & Sewage 84 (1937): 142-145.

78. Joseph Beardsley, "Effect of the Installation of Water Meters in Cleveland", Journal of the Cleveland Engineering Society 2 (1910): 23-30. An abstract of a water meter supply by Edward Bemis, superintendent of the Cleveland Water Works, appears in Engineering Record 45 (1902): 173-174, without tabular data. Also, Cleveland Water System (1924), p. 5. The widespread introduction of the water closet and indoor plumbing of all kinds contributed to the vast increase in the period 1890-1900.

79. The change to all electric pumps reduced manpower requirements at the three station drastically: Division requires only about 29 on staff as opposed to 80 when the steam engines were in full operation; Fairmount dropped from 43 to 28; Kirtland from 40 to 10 when electrified in the 1906'. Development Plan (1972), p. III-12.

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ADDENDUM TO: HAER OH-3
DIVISION AVENUE PUMPING STATION & FILTRATION PLANT *OHIO,18-CLEV,18-*
(Baldwin Filtration Plant & Reservoir)
West 45th Street and Division Avenue
Cleveland
Cuyahoga County
Ohio

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

HISTORIC AMERICAN ENGINEERING RECORD

DIVISION AVENUE PUMPING STATION & FILTRATION PLANT
(Baldwin Filtration Plant & Reservoir)

HAER No. OH-3

This report is an addendum to a 38-page report previously transmitted to the Library of Congress in 1978.

LOCATION: West 45th Street and Division Avenue, Cleveland, Ohio

DATE OF CONSTRUCTION: 1916-17

ARCHITECTS/ ENGINEERS: R. Winthrop Pratt, Consulting Engineer
Frank H. Stephenson, Engineer, and Milton F. Stein, Assistant Engineer of Design
R.S. Jones, Engineer, and A.V. Ruggles, Assistant Engineer of Construction
Drafting Division, Cleveland Water Department

BUILDERS: John F. Casey Co., Pittsburgh, Pennsylvania (foundations)
McClintic-Marshall Construction Co., Carnegie, Pennsylvania (steelwork)
Others unknown

PRESENT OWNER: City of Cleveland

PRESENT USE: Water pumping station

SIGNIFICANCE: First put into service in 1917, the Division Avenue Pumping Station was a notable engineering achievement, representing the apogee of the steam-powered reciprocating pumping engine to furnish water to the households of Cleveland, then the nation's sixth-largest city. As built, the station was equipped with six triple-expansion steam pumping engines having capacities ranging from 10 to 25 million gallons per day. Three of these, all built by Allis Chalmers, still remained in 1974, when the station, cited as a "rare technological landmark" and said to be unique in the state of Ohio, was listed in the National Register of Historic Places. Incorporating elements of the Second Renaissance Revival style, the substantial four-story brick building that housed the engines is notable in its own right and is an integral component of a water-treatment plant sharing a common architectural idiom.

HISTORIAN: Carol Poh Miller, November 2005

PROJECT INFORMATION: This documentation was prepared under contract with MWH America, Inc., project manager for the rehabilitation and improvement of the Garrett A. Morgan Water Treatment Plant. The project involves the replacement of the existing pumping station with a new one, now under construction on an adjacent site. Following completion, the historic pumping station will be removed from service and razed to make way for a new reservoir to be built on the site. No federal funding is being used for the pumping station or reservoir projects. However, because the City of Cleveland has requested funding from the federal Water Supply Revolving Loan Account for rehabilitation of the plant's filtration system, MWH and the City of Cleveland Division of Water entered into Section 106 consultation with the Ohio Historic Preservation Office. This resulted in a Memorandum of Agreement stipulating a program of mitigation documentation. This report, together with the accompanying photographs, constitutes that documentation.

This documentation supplements the report written by Ed Pershey in 1978 as part of the HAER Cleveland Survey, conducted in 1978-79 and supervised by this author.

CHRONOLOGY

1856	First Cleveland water system put into service; water drawn from Lake Erie is pumped to a reservoir at Kentucky (West 38th) Street and Franklin Avenue by two Cornish engines.
1874	First submerged water-intake tunnel completed, and new pumping engine house (Engine House No. 2) built.
1897	New pumping engine house (Engine House No. 3) built.
Late 1917	Division Avenue Pumping Station, built on the site of Engine House No. 3 and incorporating two of the old plant's steam pumping engines, completed at a cost of $1,220,000 and put into partial service.
1918	First year of full operation.
1945	First electric motor-driven centrifugal pumps installed.
1953	First of station's six steam pumping engines removed (the Kilby engine of 1898) and replaced by electric motor-driven centrifugal pump.
1972	New raw water pump house put in service; raw water turbines removed from Division Station.
1977	The last triple-expansion steam pumping engines scrapped.
1991	Division Station renamed to honor inventor Garrett A. Morgan.
1999	Camp Dresser & McKee recommends replacement of pumping station.
2001	Ground broken for new pumping station.
Late 2005	New pumping station begins operation; old pumping station remains on stand-by.
2006	Old pumping station removed from service and demolished.

BUILDING DESCRIPTION

The Division Avenue Pumping Station was an integral component of the Division Avenue Water Treatment Plant (now known as the Garrett A. Morgan Water Treatment Plant), an architecturally unified campus designed for the treatment and delivery of potable water to West Side areas of the city and its suburbs. It is located at the foot of West 45th Street, between the Cleveland Memorial Shoreway and Division Avenue, on the south bank of the old Cuyahoga River bed. It is a large four-story building, T-shaped in plan, of steel-frame construction. It is founded on piles and rests on concrete footers, with brick above grade; there is a molded brick water table. The walls, of textured brick in multiple shades of brown, are laid in Flemish bond. Hipped and gable roofs of Spanish tile have deep eaves with copper soffits, brackets, gutters, and downspouts, all now handsomely patinaed.

The building, which faces west, is symmetrical in plan and design. The rectangular main block, 285' x 151' in size, incorporates pavilions at north and south ends. Projecting from the rear (east elevation) is a four-story boiler house, 96' x 101' in size. As built, the north pavilion housed the low-lift pump room at ground level with offices, stores, lockers and machine shop above. The central block and south pavilion together comprised the main engine room, an open four-story space commodious enough to accommodate seven steam-powered pumping engines. (Only six were ever installed.)

The main block consists of a gable-roofed central section, eight bays wide. This is flanked, at north and south ends, by hipped-roof pavilions three bays by eight bays in size. The ground story has tall round-arch windows. In the west elevation (façade) of the central block are two entrances of equal importance, also styled with round arches. Windows and doors have brick sills and lintels. The three upper stories feature recessed ranks of pivoting factory sash, grouped in pairs, with spandrels of paneled wood. These are separated by simple brick piers whose plain surfaces carry decorative insets of lighter-toned brick in rectangle and diamond shapes.

The boiler house, six bays long and five bays wide, still houses its original equipment: six 500-h.p. Sterling boilers with Riley stokers, coal and ash bunkers, hoppers, and the conveyor system used to deliver the coal and remove the ashes. It has a low-pitched gable roof pierced by five shed-roof dormers in each slope and, in the peak, two cupola-style ventilators with hipped roofs. Like the main block, the boiler house has round-arch openings at ground level, with piers and spandrels above, though window openings are irregularly spaced, reflecting the building's functional needs. The east elevation—in essence, the "façade" of the boiler house—incorporates a four-story-high shelter for the track and railroad cars used for delivery of coal and removal of ash. Here the roof pediment is carried by four massive square brick columns. Between the columns, at the second story level, are railings of brick laid to form a decorative "X" pattern. This elevation incorporates decorative inserts of lighter-toned brick similar to those in the pavilions of the main block. In the pediment is a large oculus surrounded by decorative brickwork in the form of a four-pointed star.

Inside, the main engine room—a grand four-story space that was a fitting home for a half-dozen monumental steam engines—has been little altered. It has a coffered ceiling with brackets and walls of white glazed brick adorned by a succession of monumental bronze sconces with teardrop glass globes. An iron-railed gallery runs the length of the east elevation at the second-floor level. The floors are white mosaic ceramic tile with green geometric borders. In the northeast corner, a brass-and-iron stairway leads to the second- and third-floor rooms in the north pavilion, including offices, stores, machine shop and lavatories.

ALTERATIONS

The original entrance and doors in the west elevation have been removed and replaced, and most openings in the boiler room have been closed up. Two chimneys, each 225' high, that formerly served the boiler house have been removed, as have the railroad tracks. Inside, the main engine room is little altered, although the vast four-story space appears oddly disproportionate with the modern low-profile electric pumps it houses today. The north pavilion, which once housed the raw water turbines, stands empty save for a large "suction header" that delivers filtered water to the pumps. In the boiler house, an asbestos-abatement project has left the six boilers shorn of their fire-brick casings. Vacant and unused for almost thirty years, the boiler house and its equipment are in poor condition.

Two ancillary buildings located north of the present pumping station will also be demolished: the Screen Well House, 54' x 24' in size, which formerly screened marine life and foreign objects from the raw water before it entered the pumping station; and the Gas Meter House, which housed the station's gas meters. Erected at the same time as the pumping station, these buildings matched the pumping station in design and materials.

SUPPLEMENTAL HISTORY

In a 1946 report on the water supply needs of metropolitan Cleveland, Havens and Emerson, consulting engineers, neatly summarized the work of the Division Avenue Pumping Station: "Raw water is pumped to the filtration plants by three steam turbine driven centrifugal pumps. Filtered water is pumped into the distribution system into Low Service and First High Service, by six engine-driven reciprocating, one turbine driven centrifugal, and four motor driven centrifugal pumps." Significantly, the report concluded: "Division Ave. station should be equipped throughout with centrifugal pumps driven by electric motors, and with electric energy obtained from two sources."[1]

Over the next two decades, the recommended electrification proceeded piecemeal. Upgrades made in 1945 included the installation, for filtered water Low Service, of one 2000 h.p. motor-driven, 40 m.g.d. DeLaval centrifugal pump; and, for filtered water First High Service, two 1000 h.p. motor-driven, 10 m.g.d. Ingersoll Rand centrifugal pumps and one 1750 h.p. motor-driven, 22 m.g.d. DeLaval centrifugal pump. In 1949, Low Service was augmented with one 1820 h.p. steam turbine-driven, 40 m.g.d. DeLaval centrifugal pump.[2]

By 1953, two of the plant's six triple-expansion steam engines—the 1902 Allis Chalmers and the 1898 Kilby (both rebuilt in 1916)—had been removed from service but still remained in place. That year, the Kilby engine was removed and replaced by a new 22 m.g.d. motor-driven centrifugal pump.[3]

In the early 1970s, the Cleveland Division of Water (CWD) began to plan for the complete electrification of its water treatment plants, including the Division Avenue Pumping Station. In the files of the CWD are a series of engineering drawings, prepared by Havens and Emerson and approved on March 30, 1973, for the "Division Pump Station Electrification." Two of these drawings allow comparison of the pumping station as equipped before and after the work.[4]

The "General Plan of Pump Station Existing Pumps and Piping" shows that, in December 1972, three reciprocating pumps driven by triple-expansion steam engines—one 20 m.g.d. Allis Chalmers engine and two 25 m.g.d. Allis Chalmers engines, all built in 1916—still remained in situ, as did the 40 m.g.d. steam turbine-driven pump added in 1949. All were marked for removal. Also indicated on the plan were five motor-driven pumps, ranging in capacity from 22 m.g.d. to 40 m.g.d. This equipment pumped finished (i.e. filtered and chemically treated) water to Low Service and First High Service areas of Cleveland and its western suburbs. Housed in the station's north pavilion were three (raw water) 100 m.g.d. steam turbine-driven centrifugal pumps and one First High Service (finished water) 20 m.g.d. steam turbine-driven centrifugal pump.

The "General Plan of Pump Station Pumps and Piping at Completion of Contract," as last revised on October 9, 1973, shows the 20 m.g.d. Allis Chalmers engine (located at the north end of the main engine room) replaced by two new 30 m.g.d. motor-driven pumps; one 25 m.g.d. Allis Chalmers engine (located at the center of the main engine room)

[1] Havens and Emerson, Consulting Engineers, *Summary Report: Water Supply Needs for Metropolitan Cleveland* (March 1946).
[2] Regional Planning Commission, Cleveland-Cuyahoga County, Ohio, *Sewer and Water Plan—Water Supply and Distribution* (August 1953), 20.
[3] Regional Planning Commission, 20.
[4] Drawings No. F-2470 and F-2471, Division of Water, Department of Public Utilities, Cleveland, Ohio.

replaced by two new 38 m.g.d. motor-driven pumps; and the other 25 m.g.d. Allis Chalmers engine (located in the south pavilion) replaced by a new 30 m.g.d. motor-driven pump and a modified 15 m.g.d. motor-driven pump. Upon completion of electrification in 1977, the Division Avenue Pumping Station counted a total of eleven motor-driven pumps for the pumping of finished water; five Low Service pumps, rated from 15 m.g.d. to 40 m.g.d.; and six High Service pumps, two rated at 22 m.g.d. and four rated at 30 m.g.d.

As the electrification plan proceeded, the fate of the three remaining steam pumping engines began to elicit the attention of preservationists. In a letter to Mayor Ralph J. Perk, Jerry L. Rogers, chief of the Office of Archeology and Historic Preservation of the National Park Service, wrote: "Your city possesses an outstanding engineering monument in the steam engines."[5] And Robert M. Vogel, curator of the division of mechanical and civil engineering of the National Museum of History and Technology, Smithsonian Institution, urged preservation of at least one of the engines, terming them "of extraordinary historical importance."[6] Pleas to save even a single engine, however, proved futile. By 1977, the last Allis Chalmers triple-expansion pumping engines had been scrapped.

With the steam pumping engines gone, the boiler house with its six 500-h.p. Sterling boilers lost its purpose and was abandoned. In 1976, the firm of Dalton Dalton Little Newport prepared plans for architectural modifications, including removal of the stacks and railroad tracks serving the boiler house. In 1981, the station's two 9' (internal diameter) x 225' high brick stacks were razed.

In 1991, the Division Avenue Water Treatment Plant, including the pumping station, was renamed in honor of Cleveland inventor Garrett A. Morgan, (1877 [sometimes given as 1879]-1963), who, using a "breathing device" he patented in 1912, descended into a gas-filled water tunnel beneath Lake Erie to rescue workers and retrieve bodies after an explosion on 25 July 1916. Morgan's "breathing device" was said to be the prototype for the gas mask.[7]

In 1993, the pumping station underwent its final renovation with the installation of heating system replacement piping. The Cleveland Division of Water began to prepare for demolition of the defunct boiler house by contracting for the removal of asbestos, work that included the demolition of the firebrick enclosing the boilers.

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[5] Cited in Carol Poh Miller, "An 875-Ton, Steam Driven Water Pump," *WCLV Cleveland Guide* (March 1975), 5.
[6] Robert M. Vogel to the Honorable Ralph Perk, October 3, 1974, files of the Cleveland Landmarks Commission.
[7] John J. Grabowski and David D. Van Tassel, eds., "Morgan, Garrett A.," in *The Dictionary of Cleveland Biography* (Bloomington: Indiana University Press, 1996), 322.

In 1997, the Cleveland Division of Water embarked on a "Plant Enhancement Program" to prioritize capital expenditures for the rehabilitation of the city's four water treatments plants. It retained Camp Dresser & McKee (CDM) to develop a program of improvements. In 1999, CDM issued a facilities plan report for the Morgan Water Treatment Plant. The firm recommended replacement of the existing finished water pump system, with a new one "sized to better match modal flows and reduce throttling" and "laid out to provide access to all valves, piping, and headers to facilitate maintenance." While acknowledging that "the estimated costs for pump replacement versus rehabilitation are very comparable," the consultant concluded that "rehabilitation of the existing pumps would not eliminate problems associated with the existing pump station layout, such as accessibility." A new pump station, CDM said, "will result in a better system for operation, maintenance and service."[8] The same report contained a cursory evaluation of the architecture of the existing pumping station but made no recommendations "since the building is to be demolished." The new Finished Water Pumping Station, it said, "should be designed with the original architecture in mind in order to maintain an overall aesthetic cohesiveness of the plant."[9] Constructed was estimated to cost $37,781,000.[10]

Construction of a new pumping station commenced in 2001 and was completed in 2005. Designed by Metcalf & Eddy of Cleveland, it was erected by the National Construction Company. In a nod to its predecessor, the new station employed red brick walls and a hipped roof of Spanish tile.

POSTSCRIPT

In the summer of 1974, the author visited the Division Avenue Pumping Station and was privileged to see two of the remaining steam pumping engines at work, together with the boilers that supplied the life-giving steam. A longtime employee recalled that there were once park benches on the landscaped grounds as well as in the main engine room, which were open to the public. It was not uncommon for residents living nearby to visit the plant on Sunday afternoons to see the steam engines and watch the rotation of the great 20' flywheels. In 1975, Edward A. Reich, a staff member of the Cleveland City Planning Commission, observed of the Division Avenue Pumping Station that it "perhaps anachronistically represents making something technologically interesting manifest to the public. The pump house was constructed and operated with the notion that machines are benevolent and aesthetic objects and so should be housed in an environment beneficial to people, in a building built so that people could go and see the marvels of the machine age."[11]

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[8] "Cleveland Division of Water Plant Enhancement Program, Morgan Water Treatment Plant, Facilities Plan Report," prepared by Camp Dresser & McKee, Cleveland, Ohio (October 8, 1999), 5-81, 5-86.
[9] "Cleveland Division of Water Plant Enhancement Program," 6-24.
[10] "Cleveland Division of Water Plant Enhancement Program," 1-4.
[11] Miller, 4-5.

SOURCE NOTES

In the *Annual Report of the Departments of Government of the City of Cleveland for the Year Ending December 31, 1914*, p. 31, the Division of Water reports, with respect to the Division Pumping Station, that on December 28, 1914, a contract was made with the Allis Chalmers Manufacturing Company for "three triple expansion crank and fly wheel pumping engines of a total capacity of 70 million gallons per day."

In the *Annual Report of the Division of Water, Department of Public Utilities of the City of Cleveland for the Year Ending December 31, 1917*, pp. 113-14 and 127-31, Chief Mechanical Engineer L.A. Quayle reports in detail on the installation and start-up of the pumping engines.

In the *Annual Report of the Division of Water, Department of Public Utilities of the City of Cleveland for the Year Ending December 31, 1918*, pp. 119-21, Chief Mechanical Engineer L.A. Quayle reports on the start-up of all components of the station's mechanical equipment and describes the troubleshooting this required. He writes (p. 119): "This station was in continuous service during the year. The average daily pumpage for this station was 68,000,000 gallons per day or 55 percent of the total water consumed."

[Cleveland Water Department?]. "Cleveland Water-Supply to Be Purified and Softened." n.p., [1917], in "Cleveland Waterworks," vertical file, Municipal Reference Library of the Cleveland Public Library, Cleveland City Hall. Reprinted by the CWD without attribution, this article includes a description and photographs of the Division Station as it neared completion. It is the source for the names of the engineers in charge of the design and construction noted in the title page of this report.

Engineering Drawings

An incomplete set of the original (Mylar) engineering drawings for the Division Avenue Pumping Station may be found in the Cleveland Division of Water, Department of Public Utilities, 1201 Lakeside Avenue, Cleveland, Ohio 44114. A selection of blueprints (#F-809 through F-829, #F-787 and #F-788) related to the filing of building permits may be found in the collections of the Archivist, Cleveland City Council, 205 West St. Clair Avenue, Cleveland, Ohio 44113.

Photographs

In addition to a panoramic view, the Western Reserve Historical Society, Cleveland, Ohio, has more than one hundred boxes of glass-plate negatives documenting the construction of all CWD facilities. These have not been organized or catalogued and therefore remain inaccessible.

ADDENDUM TO: HAER OH-3
DIVISION AVENUE PUMPING STATION & FILTRATION PLANT *OHIO,18-CLEV,18-*
(Baldwin Filtration Plant & Reservoir)
West 45th Street and Division Avenue
Cleveland
Cuyahoga County
Ohio

PAPER COPIES OF COLOR TRANSPARENCIES

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
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Washington, DC 20240-0001

ADDENDUM TO: HAER OH-3
DIVISION AVENUE PUMPING STATION & FILTRATION PLANT *OHIO,18-CLEV,18-*
(Baldwin Filtration Plant & Reservoir)
(Baldwin Filtration Plant Chemical House)
West 45th Street and Division Avenue
Cleveland
Cuyahoga County
Ohio

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

FIELD RECORDS

HISTORIC AMERICAN ENGINEERING RECORD
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HISTORIC AMERICAN ENGINEERING RECORD

DIVISION AVENUE PUMPING STATION & FILTRATION PLANT
(Baldwin Filtration Plant & Reservoir)
(Baldwin Filtration Plant Chemical House)

This report is an addendum to 48 pages previously transmitted to the Library of Congress.

Location: Baldwin Filtration Plant
City of Cleveland Division of Water
11216 Stokes Boulevard
Cleveland, Ohio 44104

Date of Construction: 1925

Architect/Engineers: Herman Kreglius, Architect
A.G. Levy and G.W. Hamlin, Engineers of Design (the latter also served as Resident Engineer.
A.V. Ruggles and A.G. Levy, Engineers of Construction and Survey
J.W. Ellms, Engineer of Water Purification

Builders: Unknown

Present Owner: City of Cleveland

Present Use: Removed from service April 2007

Significance: Put into service in 1925, the Chemical House was built to house three hydraulic jump mixing flumes as patented by Joseph W. Ellms, a Cleveland Division of Water engineer, in 1920. Ellms tested the apparatus in experiments conducted at Cleveland's Kirtland Pumping Station in 1920 and 1921. These proved the efficacy of employing the hydraulic jump—a phenomenon that occurs in nature—to perform useful work. Ellms experiments and the subsequent experience at the Baldwin Filtration Plant, where three hydraulic jump mixing flumes operated from 1925 until 2007, proved that the hydraulic jump accomplished the rapid, complete, and uniform diffusion of chemicals for water purification and did it simply, quickly, and cheaply.

Historian: Carol Poh, January 2008

Project Information:

In 2005, the Baldwin Filtration Plant underwent a large-scale upgrade of its rapid mix, flocculation, and sedimentation processes. This documentation was prepared under contract with MWH Americas, Inc., Program Manager for the Rapid Mix/Flocculation/Sedimentation Project for the City of Cleveland Division of Water.

Until 2005, raw water was pumped through dual 60-inch mains from the Kirtland Pumping Station either directly to the Chemical House or to the Fairmount Reservoir and then from the reservoir to the Chemical House. In the Chemical House, alum (later, and alum/polymer blend), a pre-treatment coagulant, was mixed into the raw water by means of a "hydraulic jump," followed by a baffled conduit. Two storage tanks with a combined capacity of 70,000 gallons and two Rotodip feeders fed and metered the coagulant.

In lieu of the hydraulic jump and baffled conduit, rapid mixing and flocculation are now accomplished by two variable speed, inline, 72-inch rapid mixers followed by four flocculation tanks, each configured with 3-stage horizontal paddle wheel mixers. The rapid mixers are located in a new concrete structure located near Gatehouse 6, and the new concrete flocculation tanks are located on the north side of the existing sedimentation basins. The new mixers disperse the coagulant and sodium hypochlorite (liquid chlorine) into the raw water, which now is delivered directly from the Kirtland Pumping Station through two new parallel mains installed along the north side of the Administration/Filtration Building.

The City of Cleveland Division of Water and MWH Americas, Inc. recognize the historic significance of the Chemical Building and the process of water purification employed there (a process patented by Joseph W. Ellms, a city engineer). Therefore, MWH Americas, Inc. commissioned the preparation of this report, together with the accompanying photographic documentation.

This documentation supplements HAER-OH-3, titled "Division Avenue Pumping Station, Filtration Plant and the Baldwin Filtration Plant and Reservoir of the Cleveland Water Supply System," prepared by Ed Pershey in 1978 as part of the HAER Cleveland Survey, conducted in 1978-1979 and supervised by this author. The earlier documentation, which considered the Baldwin Filtration Plant (including the Chemical Building) as one component of a historic water supply system, is available from the Library of Congress at:
http://hdl.loc.gov/loc.pnp/hhh.oh0123

BUILDING DESCRIPTION

The Chemical House with its attached mixing chamber was an integral component of the Baldwin Filtration Plant, an architecturally unified campus designed in the Palladian style by City Architect Herman Kregelius. It is located on the north side of Woodstock Avenue, at the rear of the C-shaped waterworks complex, which fronts on Stokes Boulevard (formerly called Fairhill Road). The building is three stories tall, rectangular in plan, and of steel-frame construction. It is founded on piles and rests on concrete footers, with brick and stone above grade. The walls, of textured brick in multiple shades of brown, are laid in Flemish bond. The building has a hipped roof of graduated slate with copper gutters. In 1982, the original doors and sash windows were replaced and all brick and stone surfaces were water-sealed as part of a "restoration and site improvements" program.

SUPPLEMENTAL HISTORY

When the Baldwin Filtration Plant, with a nominal capacity of 165 million gallons per day, was put into service in 1925, it employed a novel means of purifying the water. Housed in a brick and concrete building designated as the Chemical House, three concrete flumes, arranged side by side, were used to mix a solution of aluminum sulfate, or alum, with the raw water for the purpose of coagulating the solids. This mixing method, called a "hydraulic jump," was devised and patented by Joseph Wilton Ellms (1867-1950), engineer of water purification and sewage disposal for the City of Cleveland Division of Water.

The Ellms Patent

Ellms's "Apparatus for Water Purification" (see Appendix) had for its object "the rapid, complete and uniform diffusion or mixing in such water of solutions of chemicals or crushed and ground solid chemicals more simply, quickly and cheaply than heretofore."[1] It ingeniously employed a phenomenon of nature—"the principle known as the hydraulic jump"—that is to say, Ellms explained:

> ... when a sheet of rapidly moving water strikes a body of water which is either standing still or moving with a lower velocity, the kinetic energy of the moving stream is very largely dissipated in the form of countless eddies and whirlpools accompanied by the entrainment of large quantities of air which seethe and bubble to the surface, the standing water being also elevated just below the point of impact to a height above the level of either the inrushing or the outflowing streams.

Such a phenomenon occurs along lake and sea shores under certain conditions—the tidal bore, for example—and at the foot of high dams. But Ellms believed that he was the first to convert the energy within the jump into useful work by adding chemicals to be mixed with the water just prior to the occurrence of the jump. He did this "by means of a horizontal trough located above the upper end of the incline and notched at one side for the uniform discharge of the chemicals

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[1] Ellms, J.W., 1920. Apparatus for Water Purification. U.S. Patent 1,362,611, filed Feb. 7, 1920, and issued Dec. 21, 1920.

throughout the width of the stream." The height and turbulence of the jump depended upon the length and incline of the chute. "I have had excellent results," Ellms wrote, "with the use of a chute about 20 feet long and having a fall of one foot in seven." While his patented invention was titled "Apparatus for Water Purification," Ellms' envisioned its use by "chemical manufacturing plants, dye factories, etc.," which, he suggested, might employ multiple successive jumps, "the weir of one discharging upon the chute of the next."[2]

In 1920 and 1921, together with A.G. Levy, a fellow Division of Water engineer, Ellms built an experimental flume at Cleveland's Kirtland Pumping Station. There they tested its efficiency as a mixing device, its effect on the speed of formation of floc, the size of the floc, its settling properties, and its retentive capacity for bacteria when applied to a filter. The men later summarized their work in the *Journal of the American Water Works Association.*[3] The hydraulic jump, Ellms wrote in response to peer comment on the test results, overcame "the objectionable features" of baffled mixing chambers, which he called "costly and cumbersome," and accomplished the purpose for which it was designed. He summarized its attributes: It mixes within less than one minute a very small volume of chemical solution with the relatively large volume of water being treated; it thoroughly aerates the water as it passes through the jump; it is extremely flexible in adapting itself to variations in the rate of flow of water; it uses no more head, if as much, than is commonly required in the usual mixing chamber; and it can be produced in a small and comparatively inexpensive structure.[4] The three large flumes built at the Baldwin Filtration Plant in 1924 were designed on the basis of the 1920-1921 experiments.

A general description of the flow of water to and through the Chemical House aids in understanding its operation. Raw water was drawn from Lake Erie through a steel and concrete crib about four miles offshore, then through a brick-lined tunnel, 9 ft. in diameter and about 26,000 ft. long, to the Kirtland Pumping Station. From there the water was pumped through two raw-water mains to the Fairmount Reservoir. From the reservoir the water was lifted by centrifugal pumps in the Fairmount Pumping Station and forced through two 60-in. cast-iron mains, each about 2100 ft. long, up through the rising well inside the Chemical House to one of three hydraulic-jump mixing flumes, each having a capacity of 55,000,000 gals. per day. The purpose of the hydraulic jump was to mix a solution of alum into the raw water to help purify it. After passing through the flumes, the water flowed through a channel containing two pairs of under-and over-baffles, through gate houses, over submerged weirs, then into four coagulation basins, each having a capacity of 8,200,000 gals. From the coagulation basins, the water flowed through control gates and a conduit to the administration building, where the flow was divided into two filter galleries. From the filters, the water passed through sluice gates into one or both of the two basins of Baldwin Reservoir. From Baldwin Reservoir the water was distributed to low-service areas by gravity or to first and second high-service areas by pumps in the Fairmount Pumping Station.

In 1930, Joseph Ellms, together with three other city engineers, described the design and operation of the Baldwin Filtration Plant in a paper published by the American Society of Civil

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[2] Ibid
[3] See A.G. Levy and J.W. Ellms, "The Hydraulic Jump as a Mixing Device," *Journal of the American Water Works Association*, 47 (January 1927): 1-26.
[4] Ibid., 26

Engineers. The paper included a thorough description of the Chemical House with its mixing flumes, from which the following summary has been taken.[5]

The Alum Storage House

Because there was no railroad connection to the Chemical House, an Alum Storage House was built on a spur track of the Cleveland Short Line Railroad south of the Fairmount Pumping Station and about one-half mile west of the Baldwin Plant. The reinforced-concrete and brick building was 51 ft. by 87 ft. in plan and 43 ft. high. The building was equipped with a dust collector system. Electric current for the building was supplied by generators in the adjacent Fairmount Pumping Station. Like the Baldwin Plant, it was designed by City Architect Herman Kregelius.

The alum was unloaded from rail cars into a counterweighted chute. The chute fed onto an apron conveyor, which fed a roll-crusher. (If the alum was fine when received, the crusher was by-passed.) The crushed alum was carried by bucket conveyor to the top of the building, where any one of three screw conveyors carried it to four hopper-bottomed storage bins having a total capacity of 1000 tons. Beneath the four storage bins were four motor truck bays. Trucks filled from these bins carried the alum to the Chemical House.

The Chemical House

The alum was brought into the three-story building at ground level and dumped through manholes in the floor into storage bins. Beneath the bins was a tunnel equipped with a narrow-gauge (24-in.) track with turntables. The alum was drawn from hoppers into a circular-bottom dump bucket located on a car. The car was moved into a hoisting shaft, and the bucket was carried to the top floor of the building by a motor-driven hoist. There the bucket was moved by monorail to a scale, then transferred to a position above a circular opening in the cover of one of six dissolving tanks. The bucket was lowered until it rested on the cover. The bottom gate was opened, discharging the alum into the dissolving tank. The dissolving tanks (each was 6 ft. 6 in. by 5 ft. in plan and 6 ft. 9 in. deep) were connected to four solution tanks (each was 15 ft. 4.5 in. by 18 ft. 3 in. in plan and 10ft. deep). The dissolved alum-in each battery of three dissolving tanks could be discharged into two of the solution tanks. Here the alum was diluted to the required strength,[6] then flowed by gravity to rate controllers located just above the rising well. From the rate controllers, the alum solution flowed by gravity into a V-shaped lead-lined distribution trough extending the length of the rising well. On the downstream side of the trough, lead "lips" spaced 2 ft. 6 in. apart discharged the solution into the rising well.

The raw water entered the building through two 60-in. mains and passed through two Venturi tubes 30 in. in diameter. Meters indicated and recorded the rate of flow and total flow. The raw water was discharged into the rising well, which was 10ft. wide and extended across the entire width of the chemical house. From the rising well the water flowed through a shallow channel to

[5] J.W. Ellms, G.W. Hamlin, A.G. Levy, and J.E.A. Linders, "Baldwin Filtration Plant, Cleveland, Ohio," *Proceedings of the American Society of Civil Engineers,* February 1930, 201-60.
[6] Alum use varied from 0.8 grains per gallon to 1.5 gains per gallon depending on the condition of the raw water.

the entrance of three parallel hydraulic jump mixing flumes. Here the water rushed down an incline, dropping 3 ft. in a distance of 20 ft. and reaching a velocity of 10ft. per second. Upon coming in contact with the relatively still water at the foot of the slope, turbulent churning occurred, resulting in rapid and thorough mixing of the alum solution with the raw water. The three flumes converged in a conduit section where the floor dropped about 9 ft. and the sides narrowed into a conduit about 19 ft. wide, 13 ft. deep, and 90 ft. long leading to Gate House No. 1. Here the water passed through a pair of under-and over-baffles to the coagulation basins.

The Chemical House was equipped with an electric passenger elevator having a capacity of 2,500 lb. In addition to being a convenience to the work force, it could be used to carry alum up from the bins to the dissolving tanks should the bucket hoist fail to operate. A dust-collecting system consisted of seven hoods (one over each possible loading position of the bucket), collector piping and valves, and a dust arrester with a discharge hopper and outlet equipped with a dust valve and canvas spout. The fan was driven by a 10-h.p. electric motor running at 1160 r.p.m.

The construction of the Baldwin Filtration Plant and Reservoir, together with all allied projects, was completed in just over three years and eleven months' time, at a total cost of approximately $10 million. The Chemical House and mixing flume, including substructure, superstructure, and equipment, were built at a total cost of $627,901; the Alum Storage House, $131,073. Their design and construction were handled by the Engineering Department of the Division of Water, with A.G. Levy and G.W. Hamlin serving as engineers of design. G.W. Hamlin also served as resident engineer. City Architect Herman Kregelius designed all the superstructures in connection with the project. Excavation for the Chemical House began in February 1925.[7] The first chemically treated water passed through the coagulation basins on September 23, 1925.[8]

Evaluating Ellm's Hydraulic Jump

In their 1930 paper, Ellms and his three co-authors asserted that the Baldwin Filtration Plant and Reservoir contained engineering features "which should be of interest to all those engaged in the design and construction of works of this type."[9] Among other features, they cited the hydraulic-jump mixing flumes as "a departure from the old methods of mixing chemical solutions with the water to be treated."

In the second edition of his book, *Water Purification,* published three years after the Baldwin Plant was put into service, Ellms cursorily, if not dismissively, described the other methods of mixing chemicals for water purification then employed—baffled mixing chambers and mixing tanks with mechanical stirring devices—while highlighting his own invention. The "simple" structure, he wrote, required "comparatively little space and a small amount of material for its construction" to produce a "mixing effect ... with great rapidity and with remarkable thoroughness." Ellms reported that mixing by means of hydraulic jump "has been employed at quite a number of plants with very satisfactory results." The largest was Cleveland's Baldwin

[7] Western Reserve Historical Society, Picture Group 356, George W. Hamlin Construction Photographs, Container 1 of 3.
[8] Ellms, et al., *Proceedings,* 253-54.
[9] Ellms, et al., *Proceedings,* 259-60.

Filtration Plant, with a capacity of 165 m.g.d.[10]

In a 1931 reprint of Ellms, et al., *ASCE Transactions* included discussion by several civil engineers. One, S.M. Van Loan, reacted guardedly, writing, "It would be interesting to know whether the [hydraulic jump mixing flume] has given the results which were hoped for ... and if it bears out in actual operation the expectations that were forecast by the experimental flume."[11] Another of Ellms's peers, Harry N. Jenks, noted that mechanical mixing devices were "deservedly gaining favor among designing engineers and operators of water treatment plants" because of the desirability to provide for variable mixing velocities.[12] Still another engineer, E. Sherman Chase, expressed reservations. "[The hydraulic jump] has the obvious advantage of simplicity and absence of mechanical equipment," he wrote. "On the other hand, there is a loss of head involved of approximately 2 1/2 ft, which could have been largely avoided had mixing tanks equipped with stirrers been installed. Furthermore, stirring devices capable of being operated at variable speeds permit somewhat greater flexibility of operation than flumes of fixed dimensions." Chase went on to question the application of aluminum sulfate in solution rather than by dry feed, which he described as "a departure from what seems to be the present trend in filter plant practice."[13]

The Cleveland engineers answered the question relative to operating results by calling attention "to the results obtained from five years of successful operation. These flumes have efficiently mixed the alum solution with the raw water, and the flocculation following the jumps has been entirely satisfactory." On the matter of solution versus dry feed, they agreed it departed from the general trend of present-day practice, but contended that "experience has shown that accurate and uniform, and consequently economical, application of the coagulant has been obtained at the Baldwin Plant... The writers are firmly convinced that the continuous uniform measurement of a liquid is more accurately and more easily obtained than the continuous measurement of solid particles." While conceding the loss of head, they stood their ground, questioning whether any form of mechanical stirring could produce a "commensurate initial jarring of the water."[14] Indeed, eighty years hence, it is hard to come to any solid conclusions about the efficacy of the hydraulic jump. The technology was adopted by several other water plants, notably Cincinnati's Richard Miller Plant, and one Cleveland water plant manager, since retired, stands by the usefulness of Ellms's hydraulic jump, praising it as a "great innovation" that was ahead of its time. In particular, he points to its lack of mechanical parts and the fact that it required no energy to operate.[15]

The hydraulic jump at the Baldwin plant remained in service until April 2007. In the intervening years, however, the Chemical House was modified in several significant respects. In 1930, the ammonia-chlorine process of disinfection was introduced to solve the problem of objectionable

[10] *Water Purification,* 2nd ed. (New York:McGraw-Hill, 1928), 74-77.
[11] J.W. Ellms, et al., "Baldwin Filtration Plant, Cleveland Ohio, " *American Society of Civil Engineers Transactions* 95 (1931): 519.
[12] Ibid., 520.
[13] Ibid., 529-30.
[14] Ibid., 530-32.
[15] Telephone conversation with Robert L. Eagleton, Cleveland, Ohio 11 January 2008.

taste blamed on "contaminating wastes" traced to the city's by-product coke oven plants.[16] By 1945, activated carbon was also being introduced by gravity feed from the top floor of the Chemical House and sluiced upstream from the hydraulic jump mixing flumes.[17] Following a chlorine leak in 1969 that caused two deaths and the hospitalization of 33 residents living nearby,[18] the plant switched to sodium hypochlorite (liquid chlorine), installing two 10,000-gal. tanks outside the Chemical House, from which it was fed by pneumatic pumps. The liquid chlorine system was later replaced with a gaseous chlorine system located at the Fairmount Pumping Station. By the 1980s, liquid alum was being delivered by tanker truck and piped to the third-floor dissolving tanks. The dry alum delivery infrastructure, including the alum storage house, was abandoned.

The author wishes to thank Robert L. Eagleton, Baldwin plant manager during the 1980s, for explaining the operation of the Chemical House during his tenure there.

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[16] J.W. Ellms, "Use of Preammoniation at Cleveland, Ohio, Filters," *Water Works Engineering,* 24 September 1930, 1458+.
[17] "Baldwin Filtration Plant, Division of Water and Heat, Department of Public Utilities, City of Cleveland, Ohio," typescript, [1945?], files of the Municipal Reference Library, Cleveland City Hall.
[18] "Chlorine Leak: The Story Behind It," *Cleveland Plain Dealer,* May 27, 1969.

Appendix

J.W. Ellms, Apparatus for Water Purification, Application Filed Feb. 7, 1920.